INTEGRATING SMART GRID SOLUTIONS WITHIN EVERYDAY LIFE

A STUDY OF HOUSEHOLD PRACTICES IN RELATION TO ELECTRIC VEHICLES AND TIME-OF-USE PRICING

Friis, Freja

DOI (link to publication from Publisher):
10.5278/vbn.phd.engsci.00115

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

INTEGRATING SMART GRID SOLUTIONS WITHIN EVERYDAY LIFE

A STUDY OF HOUSEHOLD PRACTICES IN RELATION TO ELECTRIC VEHICLES AND TIME-OF-USE PRICING

BY
FREJA FRIIS

DISSERTATION SUBMITTED 2016

AALBORG UNIVERSITY
DENMARK

INTEGRATING SMART GRID SOLUTIONS WITHIN EVERYDAY LIFE

A STUDY OF HOUSEHOLD PRACTICES IN RELATION TO ELECTRIC VEHICLES AND TIME-OF-USE PRICING

BY
FREJA FRIIS

DISSERTATION SUBMITTED 2016

Dissertation submitted:	May 30, 2016
PhD supervisor:	Professor Kirsten Gram-Hanssen Aalborg University
Assistant PhD supervisor:	Senior Researcher Toke Haunstrup Christensen Aalborg University
PhD committee:	Professor Susse Georg (Formand) Aalborg Universitet
	Lektor Malene Freudendal-Pedersen Roskilde Universitet
	Professor Marianne Ryghaug Norges Teknisk-Naturvitenskapelige Universitet
PhD Series:	Faculty of Engineering and Science, Aalborg University

ISSN (online): 2246-1248
ISBN (online): 978-87-7112-717-1

Published by:
Aalborg University Press
Skjernvej 4A, 2nd floor
DK – 9220 Aalborg Ø
Phone: +45 99407140
aauf@forlag.aau.dk
forlag.aau.dk

Printed in Denmark by Rosendahls, 2016

AUTHOR CV

Freja Friis has a background in Social Science and Geography (cand.scient.soc) in sociology) from Roskilde University. Her Master's dissertation focused on citizen participation and user-driven urban strategies based on a study of innovative temporary planning and transformation processes. Her primary methodological experiences comprise qualitative case studies, including field work and qualitative interviews. Freja is a part of the Sustainable Cities and Housing Research Group, which is 'institutionalized' at the Danish Building Research Institute (SBi). This group works with themes including energy consumption in everyday life and households' use of smart technologies. As a research assistant at SBi (2009-2011) she gained experiences of investigating regional development, sustainable building standards, social housing, and citizen participation. Her PhD is concerned with smart grid technologies, as reflected from a household perspective. Her interest in how to engage citizens in planning processes led this investigation to additionally focus on how households are actively involved in developing sustainable smart grid solutions. Thus, this inquiry acknowledges households' and consumers' commitment and engagement as fundamental for enabling sustainable transition in existing social practices. The PhD forms part of the ERA-Net funded project 'Integrating Households in the Smart Grid' (IHSMAG).

SUMMARY

The political target for a complete transition of the Danish energy system to renewable energy sources by 2050 raises the challenge of finding solutions for how to balance intermittent energy generation, from wind and solar renewables, with households' electricity consumption. Hence, demand-side management and time shifting electricity consumption attract growing interest from policymakers and researchers, as well as from commercial utilities and companies. Overall, intelligent information and communication technologies are assumed to balance electricity consumption and production better by controlling electricity demand automatically, without interrupting households' micro-social worlds or energy-consuming practices.

This thesis appraises two potential smart grid demand management strategies, by exploring Danish households' experiences of integrating electric vehicles (EVs) and 'static time-of-use pricing' in their everyday lives. The investigation examines the Danish demonstration project entitled 'Test an EV', which aimed to test the adoption of EVs amongst a variety of households. A small sample of test-drivers were additionally offered static time-of-use pricing during the test-period in order to understand how these interventions could, in combination, shift householders' everyday electricity consumption patterns from peak-demand hours to periods of lower-demand. The electricity operators particularly attempted to encourage time shifting for potentially time-flexible domestic electricity consumption practices (including dishwashing, laundering and EV charging) by using economic incentives, engagement strategies and information provision. These strategic interventions align with the mainstream techno-rational vision of how to provide the flexibility required to balance the electricity grid.

Crucially, this thesis goes beyond this dominant assumption of consumers as 'correctly' acting micro-operators that consume electricity in synchrony with renewable power generation. Using practice-based analytical approaches, this thesis investigates the interaction between smart grid technologies (i.e. EVs and static time-of-use pricing initiatives) and householders' everyday habits and routines, focusing on key energy-consuming domestic practices. The qualitative empirical results demonstrate how householders' ability to time shift challenges the temporality of routinised everyday domestic practices, with 'knock-on' effects on the timings of other practices, which are therefore experienced as stressful and inconvenient. Instead, this thesis takes its origin in the growing recognition of the need to investigate the social dimensions associated with integrating smart grid

technologies within everyday life. Further, analysis of the smart grid operator's automobility intervention underpins the need for an alternative explanation of the (s)low adoption of EVs in Denmark (and further afield), and emphasises the urgent need to understand and intervene in complex systems of interrelated and overlapping social practices, in order to challenge current mobility paradigm.

The intervention, reproduced and changed (or reinforced) pilot householders' social practices, and demonstrated how smart grid technologies can also encourage new (unintended) resource-intensive consumption practices. It is therefore argued that future smart grid interventions for the decarbonisation of society, need to recognise the dynamics of interwoven temporal systems of social practices, which require much greater understandings of everyday practice performances, and how they systemically interrelate and overlap, than currently held within policy, industry or the Academy. Instead of reproducing the dominant techno-rational 'smart' paradigm, reframing the 'smart' utopia, a transitioning to a less energy-intensive society, must be based on in-depth understandings of the interplay between technological interventions and real-life conditions. In addition, future interventions need to challenge widely-held assumptions about what constitutes 'quality of life', and whether this can be decoupled from resource-intensive consumption practices.

SAMMENFATNING

Det politiske mål om at transformere det danske energisystem til 100 % vedvarende energi i 2050 indebærer nye løsninger i forhold til at balancere den fluktuerende elproduktion fra vind og solenergi med elforbruget. Balancen kan opnås ved et mere fleksibelt elforbrug, der indrettes efter elproduktionen fra vedvarende fluktuerende energikilder. De seneste år, har potentialet for at aktivere det fleksible elforbrug gennem udviklingen af 'smart grid'-teknologi vundet stadig større opmærksomhed blandt politikere, forskere, energiselskaber og private virksomheder. Den gængse forestilling af 'smart' bygger på visionen om at udvikle intelligente teknologier der kan skabe balance i energisystemet uden grundlæggende at påvirke forbrugernes sociale situation og energiforbrugende praksisser.

Denne afhandling undersøger danske husholdningers erfaringer med at integrere smart grid-løsningerne; elbiler samt dynamiske nettariffer i deres hverdagsliv. Undersøgelsen har taget udgangspunkt i det danske demonstrationsprojekt 'test-en-elbil', som gik ud på at teste første generations fabriksfremstillede elbiler blandt et bredt udvalg af danskere. Et lille udvalg af 'test-piloter' fik desuden tilbudt timeafregnet elforbrug i test-perioden for at undersøge hvorvidt denne kombination kunne rykke husholdningers elforbrug til tidspunkter med lavt energiforbrug. Målet med testforløbet var at flytte elforbruget gennem økonomisk incitamentstyring, engagement og oplysning. Forventningen var at elforbruget på opvask, tøjvask og opladning af elbilen, som generelt anses for værende de mest fleksible forbrugsområder, blev flyttet til om natten, hvor elprisen var lavest. Denne tilgang reproducerer den grundlæggende dominerende opfattelse af, at økonomiske incitamenter og intelligente teknologier er løsningen på at skabe den nødvendige fleksibilitet hos forbrugerne.

Dette projekt stiller sig kritisk overfor den dominerede forståelse af forbrugere, som potentielle micro-operatører, der er i stand til at handle korrekt og bruge strøm synkront med produktionen af vedvarende energi. Gennem pendulering mellem praksisteoriens analytiske tilgang og de empiriske fund, undersøger afhandlingen indvirkningen af smart grid-teknologier på husholdningers hverdagsrutiner og vaner med særligt fokus på energiforbrugende praksisser. Således belyser denne afhandling gennem kvalitative metoder, hvordan husholdningers flytning af elforbrug udfordrer og udfordres af hverdagens rutiner og vaner tilknyttet tidsbestemte udførelser af praksisser. Studiet tilslutter sig dermed den stigende erkendelse af de 'sociale' dimensioner i forbindelse med integration af smart grid-

teknologier i husholdningers hverdagsliv. Analysen af elbilsoperatørens intervention underbygger behovet for en alternativ forklaring på den langsomme udbredelse af elbiler samt for at intervenere i de komplekse systemer af sociale praksisser og dermed udfordre eksisterende mobilitetsparadigme.

Interventionen i hverdagspraksisser viser, hvordan smart grid-teknologier kan medføre nye ressource-intensive forbrugspraksisser. Afhandlingen understreger nødvendigheden af at fremtidige smart grid-interventioner og dekarboniseringen af vore samfund tager højde for de sammenvævede systemer af sociale temporale praksisdynamikker, hvilket kræver langt mere komplekse og nuancerede forståelser af husholdningers hverdagsliv end dem som dominerer nutidens politik, forskning og udvikling. Fremfor at reproducere dominerende tekno-rationelle tilgange, bør en reformulering af 'smart' utopia og omstillingen til et bæredygtigt mindre energi-intensivt samfund baseres på dybdegående forståelser af sammenhænge mellem teknologi-interventioner og det sociale liv, samt ændre eksisterende opfattelser af 'livskvalitet' som tætforbundet med ressource-intensive forbrugspraksisser.

MANDATORY PAGE

Title: *Integrating smart grid solutions within everyday life: A study of household practices in relation to electric vehicles and time-of-use pricing.*

PhD Student: Freja Friis
Main supervisor: Kirsten Gram-Hanssen
Co-supervisor: Toke Haunstrup Christensen

The thesis comprises four papers:

Paper I	Toke Haunstrup Christensen, Kirsten Gram-Hanssen & Freja Friis (2013) Households in the smart grid: existing knowledge and new approaches, in Hansson, L., Holmberg, U. & Brembeck, H. (red.) *Making sense of consumption: Selections from the 2nd Nordic Conference on Consumer Research 2012*. Göteborg: Centre for Consumer Science, University Gothenburg. Kap. 20, pp. 333-348.
Paper II	Freja Friis & Kirsten Gram-Hanssen (2013) *Integration of smart grid technologies in households – how electric vehicles and dynamic pricing change social practices in the everyday life*. ECEEE 2013 Summer Study Proceeding, European Council for an Energy Efficient Economy, pp. 1019-1030.
Paper III	Freja Friis & Toke Haunstrup Christensen (2015) *The challenge of time shifting energy demand practices: Insights from Denmark*, resubmitted to Energy Research & Social Science.
Paper IV	Freja Friis (2016) *Making sense of electric driving: exploring mobility intervention in practices*, will be submitted to Energy Policy.

The thesis is based on the above submitted or published scientific papers. Co-author statements and supervisor statement are sent to the assessment committee and are also available at the PhD administration.

ACKNOWLEDGEMENTS

Despite energy use and consumption largely being silent and unconscious practices, I am aware that the energy used by my mind and body, from the pure beginning of this journey and throughout, has been generated by the support and positive feedback ‘effects’ of a variety of people:

First and foremost thanks Kirsten Gram-Hanssen for guiding me through the energy and consumption research field, and helping me to understand how significant households’ electricity consumption is for enabling sustainable transitions. You opened my eyes to the social dimension of energy use and encouraged me to jump into the right ‘research’ outfit. Thanks for believing in me, when I lacked confidence myself, for being caring, when I most needed it, and for giving me the most valuable supervision within my research field that you can imagine.

Also a grateful thank to my co-supervisor Toke Haunstrup Christensen, for showing me how fun, experimental and enlightening it can be to write a scientific paper. Every paper discussion meeting provided me with new tools and insights about academic writing, as well as new scientific approaches and reflections. Further, I am a big fan of how you always retain a friendly, humorous and optimistic approach throughout the scientific research process.

Thanks to the research fellows from Norway and Spain who were a part of the IHSMAG project, from which this PhD is financed. Thanks for very inspiring meetings and qualified discussions about ‘smart’ and user-friendly designs. Specifically, your different perspectives on ‘smart’ respectively, from the system side (Norway) and technology side (Spain) have been very useful in increasing my comprehension for real-life encounters at the household-level.

Further, the three months that I spent as a visiting researcher at UEA (Spring, 2015) has proved essential for my research process. Tom Hargreaves, my guest supervisor, deep thanks for our super advisory meetings and your very useful feedback on my fourth paper, for opening my eyes to the most recent practice-based approaches and for convincing me about continuing with my analytical framework. Your keen and energetic approach certainly produced a crucial spill-over effect on me.

At my PhD office at UEA I met Rachel Macrorie, who turned my internship into an unforgettably magnificent experience. Thanks for the daily ‘fancy’ coffee talks, your theoretical and analytical advice, for helping me to finish difficult sentences in English, and not least for stimulating other sides of my brain by introducing me to the international network of ‘Urban Sketchers’, fantastic yoga training, and lovely English pubs. Also a great thanks Rachel for proofreading my thesis.

Also to my colleagues at SBi I owe great thanks. In particular, a huge thanks to my PhD fellows Line, Anders and Mette for sharing frustrations and successes and for helping me to traverse a sometimes tricky path. Thanks Rikke for showing me how structure and discipline mix very well with good chocolate and red wine after effective writing hours in the summerhouse.

This journey would never have been completed without the support and qualitative time with my family and friends:

Mette Mønsted – thanks for being my ‘substitute father’, and for really inspiring and encouraging me to complete a PhD. Your support – professional and personal – and just the awareness about that you are always there whenever needed have been invaluable. Together with your heavenly French lunch-servings and espressos, meetings with you have proved to be some of the most effective energy ‘drivers’ of all.

My dear friends – thank you for always being there and for understanding that we need to ‘push’ our talks and fun into the future a little. I miss you all! And particularly over the last few months, thanks Christian and Thilde for being the most helpful and welcoming neighbours that you could ever wish for. Also thanks Thomas for maintaining my geographical ‘roots’ and for always providing critical and inspiring thoughts.

Last but not least, an endless thanks to my family. Without the flexibility of my Mom and parents-in-law to reschedule their everyday life in order to take care of our son, it would have been necessary to postpone the submission date of this thesis. You being the best grandparents meant that I have (almost) avoided feeling guilty for not being able to take as much care of Teodor as I would have liked over the last few months.

And finally, thanks, thanks and ever thanks to my two favourite boys in the whole world, my little son Teodor and my boyfriend Mikkel. Both of you boost me with lovely energy every day. Thanks Mikkel for always adding some craziness into my days, for taking three-months off work as a ‘house-husband’ in Norwich, and just for being such a great support and inspiration in my life.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 THE ‘SMART’ VISION

Environmental sustainability and climate change require a fundamental transition of current global energy production and consumption in less energy-intensive directions. Worldwide these challenges are expected to be accommodated by developing the ‘smart grid’, to increase the production and integration of intermittent renewable energy sources (Darby & McKenna, 2012; Joint Research Centre, 2014). Besides realising a sustainable revolution of the electricity grid, smart grid development is further anticipated (among others) to provide new models for energy provision and consumption based on renewables, to avoid peak loads by increasing grid capacity, and to aim national energy sovereignty (Christensen et al, 2013b). Since the 2000s, pioneering research and development has explored and discussed what ‘smartness’ in electricity grids would look like from different disciplinary perspectives. However, the overall debate around smart grid development has been primarily shaped by a technical vision enabled by information and communication technologies (ICTs) that are heralded as the means to adjust and control an increasing amount of intermittent fluctuating electricity in the system (Nyborg & Røpke, 2011).

Innovations such as ‘advanced metering infrastructure’, ‘smart meters’, and the ‘data hub’ are in most industrial countries anticipated to increase the amount of digitalized data and information and communication passed between consumers and grid-managers, as the means to maintain the electricity network of the future (Throndsen, 2013). Generally, this ‘smart’ vision is based on a one-dimensional model, whereby technological re-balancing of the grid occurs through smart technological equipment. This technological ideal is anticipated to control demand-side electricity consumption automatically, without disturbing or interrupting households’ micro-social worlds or energy-consuming practices (Nyborg & Røpke, 2011; Strengers, 2013). From a critical position, Yolande Strengers observes that,

> “smart technology is positioned as the ultimate utopian technology, capable of securing, improving and cleaning up the supply of electricity, as well as enabling electricity consumers to fully realise their energy management potential” (Strengers, 2013:20)

Within the smart vision, consumers are primarily predicted to be motivated to control or be controlled by smart technologies through ‘monetary incentives’. Hence, the rationale to ‘let the technology act’ is thus more or less assumed to be driven by economic incentives and different time pricing schemes (Nyborg and Røpke, 2011; Strengers, 2013:32). However, key findings from several trials and demonstrations show that this dominant technological understanding of ‘smart’, representing engineers’ and economists’ hopeful dreams, is far too narrow, and that successful flexibility depends on a much broader and complex understanding of consumers (Nyborg & Røpke, 2011:1859; Strengers, 2013:52). These views warn against being too optimistic about the techno-rational paradigm’s limited potential for developing a comprehensive smart grid design, and this is why Strengers (2013) has stressed the crucial need to reconceptualise the so-called ‘Smart Utopia’ and ‘putting’ the ‘Resource Man’ to bed (Strengers, 2013:157).

The concept of ‘smart-management-of-smart-technologies-installed-in-the-smart-digital-homes-in-the-smart-grid’ is even sometimes framed so as to enhance luxury and pleasance for householders. For example, visions that ‘funwash’ the mundane chores that produce ‘boring demand-management’, and this reinforcement of everyday consumption critically could have negative feedback consequences for total energy demand (Nyborg and Røpke, 2011:1858). Thus, an increasing number of researchers are concerned about the potential of smart grid technologies to create and reshape existing practices, and thereby ‘normalizing’ and escalating current electricity-dependent lifestyle concepts of luxury, comfort, entertainment, security, heath care, pleasance and convenience (Nyborg and Røpke, 2011:1858; Strengers, 2013:158,51). These researchers acknowledge the social dimension of ‘smart’ as essential for developing comprehensive technological solutions that work in practice (Christensen et al., 2013b; Hargreaves, 2015; Nyborg & Røpke, 2011; Schick & Winthereik, 2013; Skjølsvold et al., 2015; Strengers, 2013). Further, the European Strategic Energy Technology (SET) Plan (European Commission, 2014) recently turned away from the traditional understanding of users as passively involved in demand management to acknowledge that consumers (will) form an influential part and an increasingly active role in bringing more flexibility to the energy system and in becoming ‘prosumers’ which refers to households being consumers and producers at the same time (Christensen et al., 2013c).

1.2 ‘SMART’ IN DENMARK

Corresponding with the worldwide smart grid revolution, the Danish Government and energy sector anticipate demand-side management as fundamental to reaching the target for a complete transition. Thus, households’ flexibility to time shift their electricity consumption is essential in order to accommodate a renewable energy system by 2050 (Danish Government, 2011, 2013b; Schick & Gad, 2015). In Denmark a smart energy system requires greater exploitation of energy from wind as soon as it is produced. Alongside cheap wind generated electricity, demand-side management is expected to decrease the need to expand Denmark's electricity infrastructure. The Danish Smart Grid Strategy (2013) expects households to be prominent smart grid 'micro-operators' to release the required peak-shaving through the ability to store, produce, and use less energy by heating their homes differently, using electric heating (heat pumps), and adopting and charging electric vehicles (EVs). The most important incentive for successfully activating consumers to this end is assumed to be hourly electricity pricing schemes.

Therefore the Danish Government plans to rollout remotely-read electricity meters (read every hour) to all consumers by no later than 2020 (Danish Government, 2013a). In particular, electric vehicles and plug-in hybrid vehicles (EVs) are considered as an innovative technology for ensuring long-term flexibility in the grid, due to their ability to switch between storing and using electricity which enabling them to balance grid fluctuations for brief periods and with a short reaction time. The expectation is that EVs are able to provide valuable system services to enable reliable electricity grid operation by functioning as storage devices that can smooth out power fluctuations from renewable resources, particularly from wind power (Danish Government, 2013a). Consequently, several policy incentives have been implemented in order to stimulate EV-market penetration. Some of the significant incentives have comprised; exemption of EVs from registration, weight, and owner tax in 2013-2015 (Registration Tax Law, 2014), discounts on EV charging costs, and financial support for demonstration projects intended to help establish the required vehicle-charging infrastructure across Denmark (Danish Government, 2013a).

Despite the rise and fall of the popularity of EVs throughout history (Callon, 1986, 2012; Rezvani et al., 2015; Situ, 2009), it seems that the electrification of cars is increasingly moving beyond pilot and demonstration phases (Bakker and Farla, 2015; Dijk et al., 2013), based on EVs' vehicle-to-grid potential to balance increasing fluctuations in the grid (i.a. Bradley & Frank, 2009; Dijk et al., 2013; Richardson, 2013). Framed in the era of climate change, peak demand scenarios, rising oil prices (oil prices have been increasing for a long time, and only recently have they started to decline) and energy independence (Dijk et al., 2013, Rezvani et al., 2015; Richardson, 2013), international governance strategies have focused on formulating standards (e.g. for EV charging infrastructure) and developing increasingly stringent regulations (e.g. to boost EV manufacturing).

Prominent national strategies have also attempted to increase EV adoption through economic incentives, technological innovation, and by establishing a reliable charging infrastructure. Given the huge smart grid potential attributed to EVs and this new momentum, current global diffusion of EVs is still in the nascent stage (McKinsey&Company, 2014). Mainstream explanations of this (s)low uptake include; that EV purchase prices are too high, and that their driving range is too limited (Rezvani et al., 2015; Simic et al., 2014). In line with the overall vision of ‘smart’, these concerns illustrate the dominant technological assumptions about how EV adoption will be enabled, and sustainability transitions will be encouraged. In contrast to the techno-rational paradigm, this thesis adopts a broader socio-technical approach for accommodating decarbonisation, which pays attention to peoples’ habits and routines and multiple performances of social practices that, to a large degree, shape the social world.

1.3 PRACTICES AS INTERVENTION POINTS

This thesis takes its origin in the increasing acknowledgement of the importance of investigating the ‘social’ dimensions associated with attempts to integrate smart technologies in everyday life. Given society’s continually rising resource consumption and energy demand, this thesis attends to growing concern regarding the dominant techno-rational paradigm’s limited potential to provide the required pathways for sustainable transition. As opposed to assumptions that householders act as conscious and economically-oriented micro-operators who take the ‘right’ decisions according to ‘automatized’ electricity consumption in synchrony with renewable energy generation, this thesis recommends placing focus on the routinised and invisible part of households’ everyday consumption. To better understand the potential for new smart grid technologies to deliver sustainable energy transitions under real-life settings, this thesis advocates attending to households’ social practices and daily routines, as produced through the performance of ‘messy’ complexes of social practices (Strengers, 2013:54). Instead of current policy framings that attempt to develop and disseminate new technological ‘solutions’ and to change individuals’ attitudes, behaviours and choices (Shove, 2010a) through price signals, this investigation seeks a deeper comprehension of households’ complex dynamics of everyday social practices.

Inspired by the ‘practice turn’ in sociological theory (Schatzki et al., 2001), an increasing number of scholars have been occupied by questions of how to intervene in social life for sustainability by revealing processes of reproduction and change in forms of consumption (McMeekin & Southerton, 2012). Taking existing societal practices as a benchmark provides an analytical framework for questioning the characteristics of practices on which energy use depends (Shove & Walker, 2014). As Shove and Walker acknowledge,

> ”[i]f climate change policy is to make a difference on the scale and at the rate required, it will have to engage more overtly, and more explicitly, with the bundles and constellations of practice on which energy demand depends” (Shove & Walker, 2014:53).

This research seeks to contribute further comprehension of the complex and unpredictable dynamics of social practices, by focusing on changes in what people do everyday (and when faced with smart grid interventions in the home), and hence understanding what energy is for, and how it’s storage and use might change in less energy-intensive directions (Shove & Walker, 2014; Strengers, 2013:54,61). Instead of reproducing the conventional focus on technology and innovation, practice-based approaches focus on changing the ‘normality’ and ‘demand’ of energy as a part of everyday practices, which are inscribed and reconfigured in socio-technological systems (e.g. energy infrastructures) (Shove, 2010a; Strengers, 2013). The analysis of social practices recognises the social and cultural dimensions of consumption as fundamental to sustainable transitions and for decarbonising the current energy system. Thus, instead of reproducing the passive techno-rational understanding of consumers, practice-based approaches recognise households’ demand and consumption as ongoing configurations of social practices (Gram-Hanssen, 2011; Nyborg & Røpke, 2011; Shove et al., 2012; Shove & Walker, 2014; Spurling & McMeekin, 2014; Strengers, 2013; Watson, 2012).

1.4 MY CASE

This PhD thesis forms part of the international research project ‘IHSMAG’, an acronym for ‘Integrating Households in the Smart Grid’, which is founded on a number of case studies in the participating partner countries of Norway, Spain and Denmark. These case studies have appraised the role of households’ in the future intelligent electricity system. The overall objective of IHSMAG has been to integrate three overall perspectives that intersect at the household level: 1) Technologies (within households) – managed by the Spanish partners, 2) The System Perspective (the electricity system and administration system affecting implementation of smart grid solutions) – managed by the Norwegian partners, and 3) Electricity Consuming Everyday Practices in the Household – managed by the Danish partners. The partners within the Danish research contribution were; Danish Building Research Institute (SBi), the electric mobility operator (EMO) – ‘Clever’, and the energy company – South Energy, ‘SE’. The empirical material underpinning this thesis relates to the demonstration projects ‘Test-an-EV’ (TEV) owned by the EMO and ‘Dynamic Network Tariff’ (DNT) (cf. static time-of-use pricing) owned by SE and were hence organised by these two operators.

The demonstration project TEV’s overall aim was to test the first generation of mass-produced EVs among 1,578 Danish households living in different parts of Denmark. Framed as the greatest and most ambitious demonstration project in Northern Europe, 198 EVs were tested in 24 municipalities from 2011 to 2014. The demonstration project delivered a variety of ‘hard’ data from data-loggers installed in the cars, and ‘soft’ data from the testpilots’ experiences about driving EVs, as reported in driving books and through weekly blogging. Overall, the project provided the private company, Clever, with knowledge about EVs operational reliability, charging patterns, driving needs, and the EVs’ energy potentials and challenges for further operation. Besides Clever’s own funding and sponsorship from private companies, the demonstration project was publicly funded by the Danish Transport Authority, the Danish Energy Agency and several municipalities. Owned by five Danish utility companies, Clever’s overall business strategy is to install smart equipment to manage private EV-load management in order to save the grid for critical loads. Hence, the data produced by the EV test-driving demonstration contributed to developing the private company’s future business and operational strategy for improving EVs’ smart-grid technology potential in Denmark (Clever’s final report, 2014). Coinciding with implementation of the demo-project, Clever opened a nation-wide charging network for EVs in 2012.

Together with the energy company South Energy (‘SE’) (one of the five owners of Clever) 18 test-pilots (from Aabenraa and Sønderborg) were offered variable network tariffs and real-time pricing. For example, the offered network tariff was ten times cheaper between 12am – 6am (0.4 euro cent/kWh) than during the peak hours of 14pm – 20pm (4 euro cent/kWh). Together with the market electricity price and taxes, the total electricity price for Danish household customers is currently approximately 0.3 euro cent/kWh. The maximum variation in the network tariff represents approximately 15% of the total electricity price and hence represents a relatively weak price signal. Besides DNT, the participants were offered a spot price agreement, which is a real-time pricing scheme that follows the hour-by-hour market price of electricity on the Nord Pool Spot market. The average market price was about 4 – 5 euro cent/kWh. The DNT ran from April to November 2012, while the TEV (and DNT) trial ran from May to October 2012. Further, Clever wanted to test the difference between two ways of performing the EV battery charging; manual load management and automated load management controlled by the operator. The shift from manual to automated load management was implemented midway (three months) into the trial. None of the households participating in the combined DNT and TEV trial had electric heat pumps or photovoltaic cells (PVs); a criterion set by the project owners to ensure clarity in interpretation of the consumption data.

The combined trial aimed to test the impact of economic incentives on households' flexibility to move energy demand to periods with surplus of renewable energy in the grid in order to avoid peak-loads and in general to provide the flexibility and responsiveness that the industry may lose in the future. In particular, households' consumption patterns were expected to change in relation to practices of dishwashing, laundry activities, and EV-charging, since these activities (in addition to electric heating) are considered as time-flexible areas of domestic electricity consumption (Danish Government, 2013a; Powells et al., 2014). Like Clever, SE presumed that the participants' flexibility to postpone these activities would increase for households participating in both smart grid trials at the same time.

1.5 AIMS AND RESEARCH QUESTIONS

Instead of reproducing dominant techno-rational assumptions concerning households' interaction with smart grid interventions, my framework is rooted in a socio-technical practice-based approach that emphasises how the integration of smart grid innovations within the home is a much more complex affair. This thesis explores how EVs and pricing schemes become integrated within practices, and how this interaction both reproduces and reconfigures the temporality of household practices as well as multiple interrelations between practices in everyday domestic life. The overall objective of this thesis is to expand comprehension of the importance of taking into account the complexity of everyday household life when integrating new smart technologies. The analytical focus is to explore households' experiences related to the attempted integration of these smart grid technologies within everyday domestic routines, and in particular to comprehend the dynamics and complexities associated with efforts to change households' social practices.

Through in-depth qualitative analysis, the inquiry investigates the complexities and multiplicities associated with the rhythms, changes, and stabilities of electricity consumption patterns. The applied practice-based analytical framework goes beyond the individual subject as the central knower and decision-maker, to scrutinise the invisible routines and habits related to the integration of two innovative potential smart grid projects in the everyday. This, it is intended, will help to address the lack of research that has been conducted on integration of the end-user in smart technological design. Crucially, the aim is not to judge whether EVs and static time-of-use pricing are appropriate intervention points for sustainable transition (and decarbonisation), but rather to illuminate how such interventions change, reproduce, and constitute the social practices through which everyday life is constituted.

The overall question framing this research process is therefore: ***How are smart grid solutions, electric vehicles and static time-of-use pricing interventions, integrated within households' everyday life?***

This overall research question is divided into the following four sub-questions and supplementary inquiry points:

1. **What characterises mainstream assumptions informing the integration of households within the smart grid? (Paper I, IV and section 4)**
   - *What are the dominating visions of the role of 'smart' technologies and households in the smart grid?*

2. **What characterises the electric mobility operator's (EMOs) intervention in households' social practices? (Paper II and paper IV)**
   - *What characterises the smart grid strategy for increasing EV adoption?*
   - *How does the EMO conceptualise household practices?*
   - *How does the intervention affect household practice performances?*

3. **How does a social practice-based analytical approach provide essential alternative knowledge for integrating smart grid technologies within householders' everyday lives? (Paper I, II, III and IV)**
   - *How do smart grid technologies interplay with households' everyday routines and habits?*
   - *How does time shifting change and reconfigure households' social practices?*

4. **How can social practices be governed for sustainability? (Paper IV)**
   - *How can a system of practice research approach offer an appropriate concept for sustainable transition?*
   - *Do we need to bring 'negotiability of energy demand' onto the political agenda, and perhaps reconfigure the 'meaning' of mobility for the decarbonisation of society?*

1.6 STRUCTURE OF THE THESIS

This thesis consists of four papers. By reviewing existing demonstration projects and dominating smart grid visions and approaches, particularly within a Danish context, the first paper acknowledges the lack of knowledge about the 'social' dimensions of the smart grid and establishes the framework for investigating social practices. The second paper illuminates the interactions between smart grid technologies and everyday routines and habits, and identifies the different elements configuring new consumption practices in the households' everyday life. The third paper scrutinises the temporality of practices and acknowledges how smart grid interventions need to be aware of the synchronicity of practice performances throughout everyday life. Finally, paper four critically investigates the roles of system operators' and how they reproduce the dominant techno-rational understanding of sustainability transitions. This analysis acknowledges the crucial need for smart grid interventions to acknowledge the interlocking systems of temporality of practices.

As stated in the following section, neither the four papers, nor the above research questions, are addressed or disseminated in a linear chronological order. Due to the consistent interplay between empirical impetus and theoretical conceptualisations, the investigative approach has been adapted and refined as new understandings continually arose throughout the research process. After this introductory section **(section 1)**, I will share my methodological approach **(section 2),** followed by an introduction of the case **(section 3)**. Thereafter I introduce the existing EV-adoption approaches in policy and research **(section 4)**. I proceed by reflecting on how new insights helped to refine my theoretical approach **(section 5)**. This is followed by a thorough discussion of my empirical findings (as set out in the four research papers), together with reflections on valuable future analysis **(section 6)**. Finally, in the conclusion **(section 7)** the results of my work are drawn together. After the references **(section 8),** the four individual papers are enclosed **(section 9).**

2. METHODOLOGICAL APPROACH

This section illuminates the methodological approach used throughout this research. First, I present the case study as an overall research strategy, followed by reflections on my explorative scientific approach. Thereafter, the different empirical materials are presented, including the sampling process, data collection and analysis, followed by a brief reflection on the advantages and limitations related to follow a particular case. Finally, the progress and findings of the four papers are described.

2.1 CASE STUDY AS RESEARCH STRATEGY

As my empirical material comprises interviews with households living in particular contexts and representing specific socio-demographic circumstances, the observations made by this investigation cannot easily be applied to all Danish households. The case study is made up of a non-representative group of participants (Flyvbjerg, 2006), existing in different times and spaces, connected through a particular interest in testing EV-technology. At the same time, as Stake significantly argued,

> "[c]ase studies are of value for refining theory and suggesting complexities for further investigation, as well as helping to establish the limits of generalizability" (Stake, 1994:448).

For example, it is difficult to transfer the findings from this case study to households living in city apartments, which are not provided with the opportunity to hang clothes out to dry in their gardens or to charge EVs in their garages.

Bent Flyvbjerg (2006), in advocating the case study as valid research strategy, stressed that,

> "the most advanced form of understanding is achieved when researchers place themselves within the context being studied. Only in this way can researchers understand the viewpoints and the behaviour, which characterizes social actors" (Flyvbjerg, 2006:236).

This statement highlights how case studies critically enable in-depth context-dependent knowledge concerning the complexity of social relations to be accumulated, which in turn helps to clarify the underlying factors contributing to any given problem. Exploration and learning through case studies can therefore help unpack the complex interrelations of social practices that are critical to understand in order to enable sustainable energy transitions. In selecting a case study methodology, and describing cases of households' stories of failures and successes in relation to EVs and static time-of-use pricing, I hope to inform the design of workable smart grid interventions. This method aligns with the ontological standpoint adopted by this research of science as context-bounded, which departs from ideals of generic representative conclusions and hypothesis testing.

Rather than researching the quantitative success of particular criteria and producing 'generalisable' and 'representative' knowledge, case studies are capable of providing greater depth of insight in a context of events than other forms of analysis (e.g. surveys, which generate a series of snapshots of momentary happenings and meanings). Given the focus of this research on social practices and households' interaction with experimental technologies prior to their broader diffusion, the case study technique seems valuable for achieving in-depth insights into households' experiences over time and space. Similarly, my aim to illuminate smart grid operators' strategies and approaches within a household setting, calls a case study approach that enables interviews, observations, evaluations and email communications (with the EMO and funder) to be conducted.

Flyvbjerg describes different kinds of case studies, including extreme/ deviant cases, maximum variation cases, critical cases and paradigmatic cases (Flyvbjerg, 2006:230). My case study shares elements with both Flyvbjerg's definition of 'extreme cases' and 'critical cases' (ibid.). The purpose of the 'extreme case' is,

> "To obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense". (Flyvbjerg, 2006:230). Whereas, a 'critical case' aims to achieve information that permits logical deductions of the type, "If this is (not) valid for this case, then it applies to all (no) cases" (Flyvbjerg, 2006:230).

According to the last definition, my sample of testpilots represents an active segment of participants conventionally referred to as 'front-runners' or 'first-adopters' of innovative technologies. This is why I, to some degree, assume that challenges and problems associated with integrating EVs and time shifting as experienced by my case study participants, will gradually appear amongst other householders, who might be considered to be less dedicated, engaged and informed.

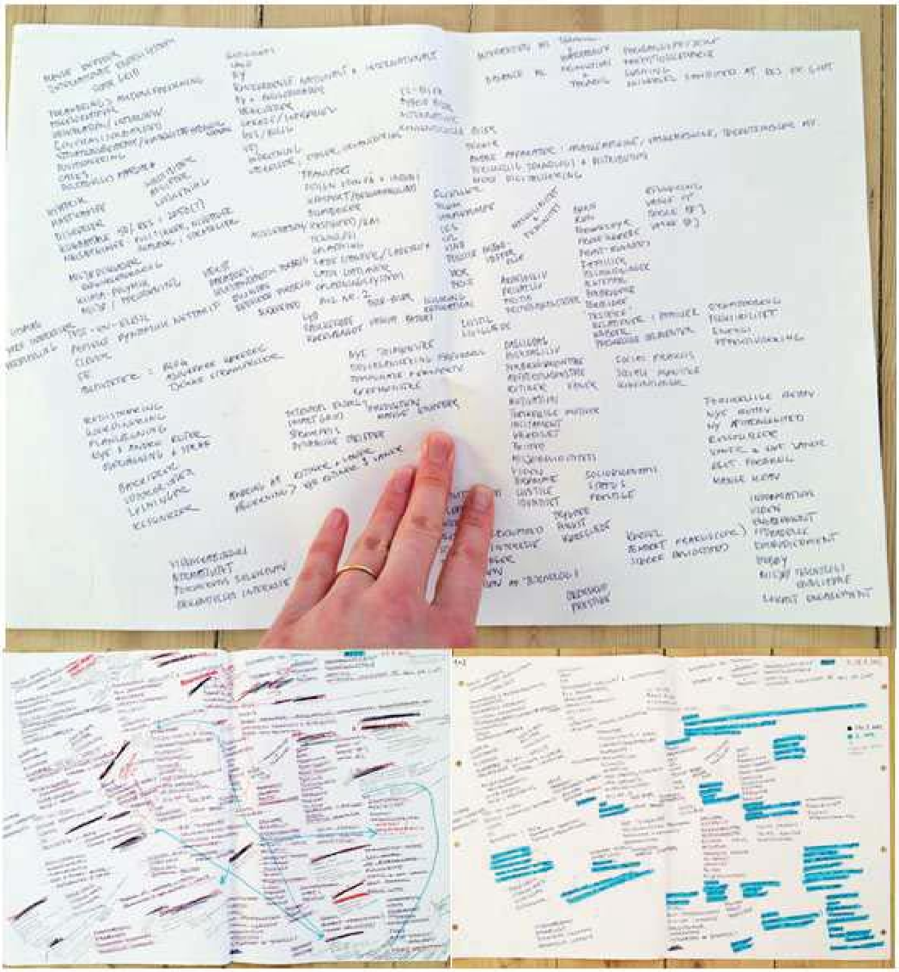
When the operator frame the extraordinarily (first time ever in Denmark) of combining EVs with static time-of-use pricing as part of smart grid intervention, this sample can be considered as extreme/ exceptional in a Danish context. Notably, Clever defines this sample as a particularly economically sensitive segment, which undermines the argument for categorising this group of 'pilots' as technological or environmental front-runners/ innovators. Further Clever retrospectively criticised the trial for encouraging plenty of free-riders who found it convenient to 'own' an extra car during the test period.

2.2 AN EXPLORATIVE APPROACH

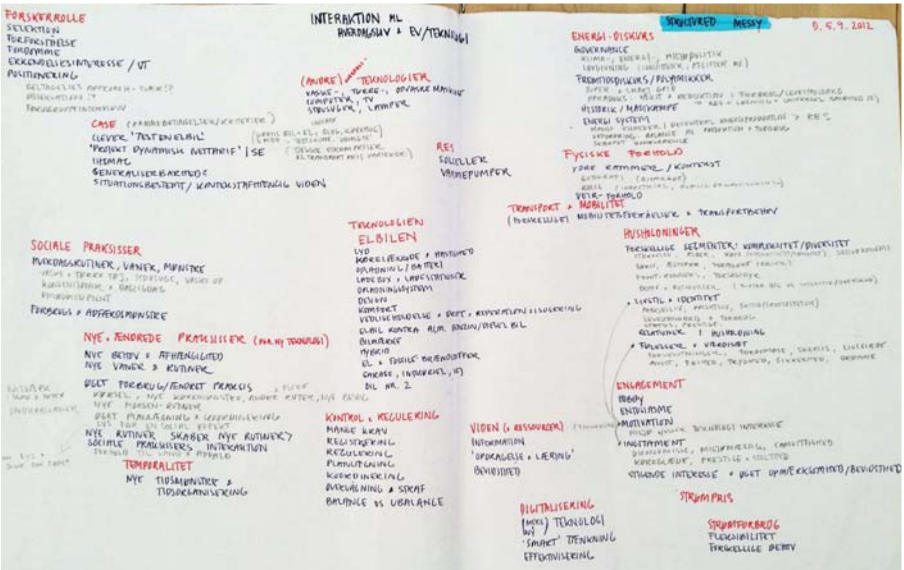
In alignment with my chosen social-practice theory based framework, my analytical approach was characterised by considering social practices as situated in specific contexts and constituted by a variety of social relations, discourses, structures, history and contextual conditions (Clarke, 2005). Significantly, the Aalborg University PhD course entitled 'Situational Analysis', which was divided into three seminars spread over eight months, also contributed to defining my analytical approach into the field. The course took its point of departure from Adele Clarke's methodological tools of mapping (ibid.), which form a significant part of Clarke's qualitative research methods, which have proven especially effective for projects within Science and Technology Studies (STS). The 'mapping' offered a useful methodology by providing a tool to 'open up' the complexity of multi-sided situational analysis as used in my research field, and improved my reflections through working with and picturing different maps (see below) which in particular increased my awareness of material elements and physical conditions. After the first seminar, I ended up being more confused than before the course started, but I soon learnt that one of the core ideas was to embrace the 'messiness' of the analytical situation. Hence, the course was helpful to embrace the chaotic process of developing new questions and ideas to follow based on what is experienced in the field. I used the three kinds of mapping: Situational maps; the Social worlds/ arenas maps; and Positional maps. I employed these mapping techniques before, during and following the first round of empirical production (Clarke, 2005:86-91).

I first produced 'Situational maps' (like 'brainstorming') to outline and investigate the interrelations between the major human and nonhuman (especially materials, objects and technologies), discursive, historical, symbolic, cultural, political, and other elements, which I expected to appear in the everyday social situations of households integrating smart grid technologies. These situational maps clarified my prejudices and increased my consciousness of my normative position. In other words, especially these scheme produced prior to entering the field, clarified the 'glasses' that I was wearing, and even more importantly, reminded me that I was wearing them, but also made me aware of new important analytical investigation points. Thus, the exercise was also helpful in opening up my eyes to the technological and material aspects of smart grid technologies in the home, which I at first found mysterious and unfamiliar given my educational roots in sociology and geography.

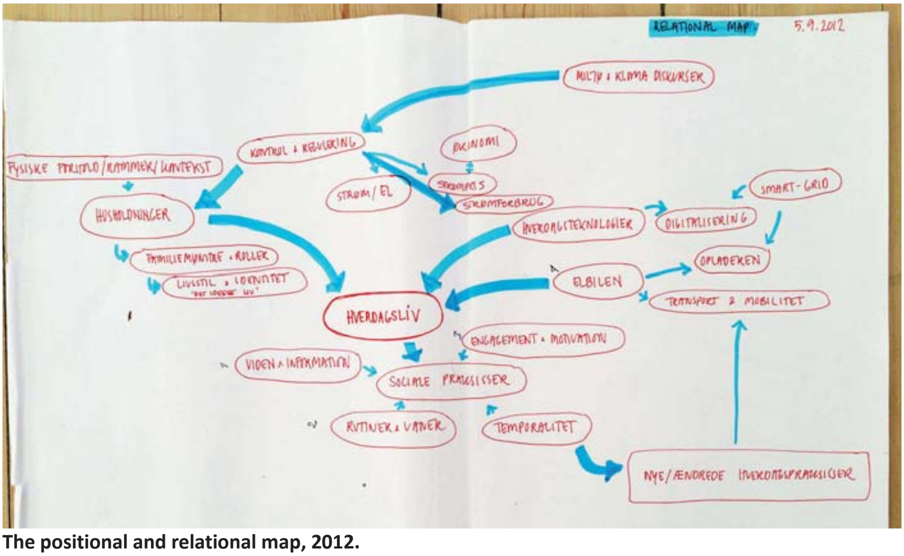
Figures 1a,1b and 1c: The methodological mapping process



These maps illustrate the situational maps, 2012



The structured messy map, 2012



The positional and relational map, 2012.

To some extent, I will argue that my ‘stranger position’ had advantages as I enter the field more open-minded and not judge the potential impact of integrating new technologies beforehand. Further, I aimed to keep in mind how empirical analysis is continually constructed from the researcher’s normative position and situational experience of particular contexts in time and space. Therefore, I sought to reflect on my role and position throughout the research process. This required constant awareness of how I continued to select, define and frame my research field However, it is also important to note that this research purpose to avoid making normative judgements about whether EVs and static time-of-use pricing form the right instruments to adequately accommodate a sustainable transition in energy.

In the philosopher Hans-Georg Gadamer's work 'Truth and Method' (from 1960), he argued that 'understanding' always is interpreted from a certain position embedded in historical and cultural contexts (Gadamer, 1989). Given these observations, the shaping of meaning in my research is invariably shaped by my pre-understandings and position while I, as an interpreter, consistently sought to acknowledge and reflect upon my existing 'prejudices' (Højbjerg, 2004:334). Some of my assumptions were for example, that the test-drivers would forget to plug-in the EV charging cable and that they would have a higher than average environmental consciousness (because of their self-applications to become testpilots). Both expectations appeared to be false, and perhaps revealed more about my own position than the experiences of the household participants.

Overall, the analytical findings were produced through a constant interaction between my empirical data and my theoretical framework. In this way, my approach shares compatibilities with the abductive approach (Coffey & Atkinson, 1996; Halkier, 2003), which aims to interpret an empirical phenomenon in the light of new interpretative frames. Through interpretation with other sets of conceptual frames, this approach attempts to shape new meanings and discover relations in empirical material. As such, adopting the method of recursive interaction between the data from my case study, and theoretical conceptions, proved very useful in structuring my analysis and identifying important dynamics in relational change processes.

The situational analysis approach proved very good for clarifying interrelated positions and connections, as well as disconnections between actors and practices. After collating my first set of empirically generated data, I attempted to illuminate the interrelated connections between and across practices among different actors (human and nonhuman agents). This might comprise the physical organisation of the house, distances between the washing machine and the clothesline, interrelational dynamics within the household, division of labour for housekeeping activities, or interviewees' relationship with the managers organising the trials. The 'Social worlds/ arena maps' were used to illuminate the commitment of different human and nonhuman elements to, and their engagement with, ongoing discourses and negotiations. The 'Positional maps' were useful in clarifying the full range of discursive positions represented in the empirical data. I performed these mapping exercises directly after every individual interview (in an EV borrowed from Clever) in order to remember as many of the senses, feelings and material aspects encountered during the fieldwork.

The different maps helped me to identify salient actions, mechanisms, procedures, dynamics, negotiations, and variations occurring where every day domestic life met with smart grid technologies. I used this very useful approach as a methodological tool to open up the variation and inter-related nature of evolving household practices (and professionals at the offices) in my fieldwork represent sites where relations and interactions between actors, technologies and a multitude of other components, interrelate and reproduce (or change) the performance of social practices. During data collection and analysis, I became increasingly concerned about the constitutive construction processes involved in producing these ‘social worlds’, and why discourses, narratives and historical settings, as opposed to the spatio-temporal performance of mundane practices, received analytical awareness within the progress.

Before introducing my empirical material, it is necessary to present the core scientific position of this thesis. Ontologically, I consider reproduction and change in social practices as enabled and shaped by structures and meanings that are reproduced through the flow of human performances. Aligning with the choice of social practice theory as my analytical framework, this thesis comprehends social life as co-constructed through the recursive relationship between socio-technical structures and human action. The elements of social practices are ‘structures’ that produce, and are reproduced, through everyday practice performances. This duality between agency and structure is important to understand the change and reproduction of human activities. In this regard, practices of domestic energy consumption are determined by structures (e.g. infrastructures, informal institutions and policy frameworks), and are simultaneously produced by the activities of individual agents. Importantly, (Schatzki et al., 2001; Shove et al., 2015) I recognise material arrangements as embedded in the constitution of social practices which make-up the social world (Shove et al., 2015).

Epistemologically therefore, the goal is to contribute knowledge about households’ ‘doings’, which I contend are inseparable intersections of human performances and wider structures of interlocking systems of practices that are situated in specific contexts (Shove et al., 2015; Spurling & McMeekin, 2014; Spurling et al., 2013; Watson, 2012). Given this, sustainable energy transitions are crucially dependent upon changing powerful material arrangements (technology and infrastructures), as well as reconstructing the meanings and embodied competences and skills that are embedded in the constitution of everyday life. And more than ‘just’ changing elements transitions are about reconfiguring systems of practice and spatio-temporal formations.

2.3 EMPIRICAL MATERIAL

The basis of my empirical analysis is formed of qualitative interviews with a variety of relevant informants (of between one to two hours duration). Interviews with the project leader and project coordinator from Clever illustrate both practical and strategic perspectives on organising the TEV demonstration project, whilst the interview with the funder from the Danish Transport Agency demonstrate arguments underpinning the allocation of public financial support for the trial. The everyday perspectives of households were gathered through two rounds of knowledge production comprising semi-structured interviews with eight participants living on the outskirts of two middle-sized towns in the South of Jutland (collected during Summer 2012), and three focus group interviews with participants (n=8) living in the northern suburbs of Copenhagen (collected in Winter 2013).

2.3.1 SELECTION OF TESTPILOTS

Of those test-drivers enrolled in the ‘Test-an-EV’ (TEV) smart grid trial, some households were also involved ‘Dynamic Network Tariff’ (DNT) trial, which offered participating households static time-of-use pricing. In total, 18 households participated in the combined test-trial and my case study was limited to this sample of particularly engaged households. Through access to the participants’ socio-economic background variables (provided by Clever), I selected eight participating households that represented the greatest variation in parameters such as; gender, age, income, marital status, household size, number of children living at home, description of motivation provided in the application to the smart grid trial, and claimed driving needs (km). The assumption was that this diversity would contribute to a broader and fuller understanding of the complex nature of households’ various interactions with the EV technology and static time-of-use pricing.

The eight households participating in the combined trial lived in detached houses in suburban areas of the middle-sized cities Aabenraa and Sønderborg, which both are situated in the South of Jutland, which is characterised as an economically declining region of Denmark. The timings of the combined trial pilot determined that my first round of knowledge collection took place early in the PhD process (Summer 2012).

I decided to undertake my qualitative interviews with these participating households at different times during the test period. Five interviews were conducted two months after the trial started, based on the idea that the households would remember how everyday life was structured prior to their engagement in the demonstration project, and simultaneously would have had the time to adapt to the trial's scripts. I also wanted to take into account individual load-management occurring during the first 2 ½ months of the trial. Further, I decided to conduct three interviews close to expiration of the trial, in order to appraise the participants' experiences and perceptions of automatic load control, and to assess how practices had been reshaped in relation to participating in the combined trial.

In addition to these eight interviews, I organised focus group interviews which differed from the majority of test-drivers (in total the project included 1578 test-pilots), because these households were recruited through their respective work places. These participating households were encouraged to enrol in the trial through advertising on their work intranet or via recommendations from colleagues. I selected this group because I originally wanted to study how much the social network within a workplace had an impact on engagement levels. Significantly, this group of testpilots did not consider that their work-place social network bore any relevance to their involvement in the trial; this is why this line of enquiry is not developed further in my analysis. Participants in the focus group interviews all represented a higher middle-class due to their common professional backgrounds (working respectively as doctors or nurses in three hospitals in the capital region). These households shared similar cultural and socio-economic 'capital' and their experiences of the combined trial could represent a group that was slightly biased towards the future smart grid vision Anticipating that common socio-economic characteristics would make it easier to shape valuable trust relations within the focus groups, I found these factors to be valuable catalysts for opening up discussions.

Table 1a: Collated significant details for interviewed test-drivers participating in the combined trial representing the first round of knowledge collection.

Individual interviews collected in Summer 2012, outskirts of two middle-sized cities South of Jutland								
Participants*	Anne-Mette	Søren	Ebbe	Hans	Mia	Viola	Hannah	Nicolas
Age and gender	61, f*	42, m*	51, m	45, m	33, f	32,f	48, f	36, m
Household size	2	4	3	2	2	4	2	4
Children	0	2h*, 1o*	1h, 2o	1h	0	2h	1h, 3o	2h
Assumed daily transport needs (km)	40-60	20-40	60-70	60-70	20-40	20-40	0-20	40-60

***'participants' names are changed to ensure anonymity.**
***'f' indicates female and 'm' indicates male.**
***'h' indicates the number of children living at home.**
***'o' indicates children no longer living at home**

Table 1b: Collated significant details for participants in the focus-gorup interviews representing the second round of knowledge collection.

Focus-group interviews collected in Winter 2013, northern suburbs of Copenhagen								
	Focus group 1			**Focus group 2**		**Focus group 3**		
Participants	Cevin	Bella	Max	Maya	Lily	Mark	Mia	Jacob
Age and gender	53, m	45, f	33, m	35, f	43, f	54, m	34, f	59, m
Household size	1	4	4	4	4	3	4	2
Children	0	1h, 1o	2h	2h	2h	1h, 1o	2h	3o
Assumed daily transport needs (km)	40-60	60-70	40-60	60-70	60-70	20-40	20-40	0-20

2.3.2 QUALITATIVE INDIVIDUAL INTERVIEWS

For the first collection of empirical data, I used the individual qualitative interview method. The goal was to gain knowledge regarding the interaction between the two smart grid projects TEV and DNT, and the recursive relationship between these and households' social practices in the everyday. I aimed to better understand how these smart grid trials interacted with households' universe of meanings, as reflected in their everyday habits and routines. The aim was therefore to explore how the two trials influenced and reconfigured households' habits and routines and *vice versa*. As previously stressed, I sought to be as open-minded and inductive as possible throughout this process whilst being alert to the fact that (re)interpretation continuously occurs.

Steinar Kvale's thoughts on the open-minded semi-structured qualitative interview (Kvale, 1996) and James Spradley's descriptive questionaire techniques (Spradley, 1979) helped me to challenge and continually reaffirm my practice theoretical lens and scientific position. Inspired by Kvale's 'InterView' (1996), I also tried to establish a trustful dialogue to open up the interviewees' 'lifeworld' and to understand their performed experiences related to time shifting and EV test-driving. Establishing the 'interView' involves an interpersonal interaction, for which I generally sought to be as informal as possible, and thus never rejected the obligatory coffee and cake offered at every home visit. Additionally, I decided to be explicit about my independence towards the two smart grid trials, clearly stating my neutral position, to help create trust relations between the researcher and informant(s).

The interview guide was semi-structured and was designed to follow significant topics/ themes that emerged around particular challenges and advantages related to participants' (re)scheduling of domestic energy-consuming practices and the (re)organisation of driving activities. Though most of the interviews only involved the person who had applied to be a 'testpilot', I sought to understand the relational dynamics occurring within the participating households, and to understand the other household members' experiences and perceptions. The 'semi' structured aspect of the interview also opened up the possibility for me to follow new significant questions, topics and paths that were (unexpectedly) revealed during the interview (Thagaard, 2004). In addition, the previous analytical process of thematically coding empirical material, developed several themes not originally included in my interview guide. Due to my abductive approach, these different analytical themes were subsequently incorporated into the interview process.

In the classical introduction to 'the ethnographic interview', the anthropologist James Spradley recommends researchers to raise 'descriptive questions' about concrete everyday routines and habits instead of intellectualize them (Spradley, 1979). Correspondingly, I used descriptive questions to open up particular aspects and obtained nuanced descriptions of interviewees' multiple varieties of practice performances and formulations of meanings, which sometimes contained ambiguous and conflicting rationales. I started out with various general questions regarding the type and organisation of activities in their everyday life and in particular *how* their typical mornings were experienced, and followed these questions with specific questions about *what* the householders actually did, *when* and over *what period of time*. This resulted in reflections about householders' 'doings' as performed in different temporalities, spaces and sequences, which always included aspects of materiality and energy consumption.

Besides considering householders' 'sayings', investigating 'doings' was imperative due to the need to understand practices as temporally unfolding and spatially dispersed nexuses of 'doings' and 'sayings' (Schatzki, 1996:89). Where 'sayings' indicate conscious 'meanings', in contrast routinised and habitual 'doings' are characterised by being mundane and normalised. Unconscious behaviour is clearly difficult to be explicit about; I therefore tried my best to make the interviewees reflect about their unconscious performances of their everyday 'doings' in the home. For example, whilst avoiding using theory, I continually asked about how they performed (due to practices always being embodied) and interacted with the materials, temporalities, and sequences of energy-consuming domestic practices. The householders' willingness to answer varied considerably. Some informants were of very few words and presumably found my continuous 'how' and 'when' questions a little banal and stupid, while others gradually followed my line of thought and gradually became more aware of their doings, and were more explicit about them as the interview progressed.

In addition, I conducted three semi-structured qualitative interviews with the managers from Clever and the funder from the Danish Transport Authority, primarily focusing on their roles as 'change agents' (Strengers, 2012). These interview guides were focused upon organisational aims and strategies, challenges and advantages of the intervention, and future interventions related to mobility operation. In particular, interviews with the project leader and project coordinator from Clever attempted to illuminate their experiences related to operationalising the demonstration project. These interviews contributed significant knowledge about what they assumed to be 'meaningful' 'smart' grid interventions, and attempted to unpack these ideas and their framing of how to enable change in testpilots' 'performances'.

The interview with the funder attempted to understand: assumptions about how to reach set decarbonisation goals for the Danish transportation sector, how TEV was a strategic initiative intended to meet these targets, the background to funding the demonstration project, the initiative's expected outputs, and the core challenges and advantages experienced by the funder in relation to TEV. These interviews with ‘professional practitioners’ were characterised by being steered to a greater extent by the interviewees’ own agenda, than those undertaken with householders, and this illustrated the eagerness and enthusiasm connected to the demonstration project.

The above reflects my epistemological aim to comprehend practice configurations and changes generated by professionals involved in the intervention. As I describe later in this thesis, I developed a growing interest in exploring how organisational meanings are constructed, and how these constructions influence the performances of everyday social practices within the household. The epistemological aim, to understand the relations between professionals and households practices, indicates how my theoretical lens inherently steered the methodological process. All the interviews were transcribed and selected parts have been translated into English.

2.3.3 FOCUS GROUP INTERVIEWS

The qualitative individual interviews provided a foundation for understanding how ‘meaning’ is constructed through the performance of everyday household practices. Whilst this method is useful for conducting in-depth studies of peoples’ ‘life worlds’, focus group interviews help to explore how ‘meaning’ is constructed through social interactions between people (Morgan, 1997:2,15). Due to the limited capacity of EV batteries and weather sensitivity, my presumption was that the test-drivers’ experienced meanings would be more significant during the Winther period. Further, I wanted to explore the test-drivers’ flexibility to postpone their practices, without any economic incentives that were designed to encourage the charging of EVs during the cheaper nightly tariff periods.

The ability to organise and carry out focus groups interviews at two work places (Copenhagen University Hospital and Herlev Hospital), and not in participants’ homes, proved logistically useful. In addition, I experienced how our relations (as interviewer vs respondent) were more balanced due to the participants’ more active role as focus group co-organisers. For example, my first group interview took place in one of the laboratories connected to the Copenhagen University Hospital, where participant responsible for organising the meeting point had ‘booked’ the kitchen, brewed coffee, lit candles etc.

From the PhD course ‘Focus group interviewing as research tool’, which was led by one of the experts in the field, Bente Halkier, I learnt useful tools to help facilitate this qualitative method. As a ‘moderator’ I aimed to stimulate the participants’ reflections about sense making related to EV-driving, and to discover their normative positions as revealed through the collective performance of these group discussions. Reflecting Halkier's recommendations (Halkier, 2002), I had developed a clear idea about how to organise, structure, and moderate the focus groups in advance of their organisation. In order to stimulate engagement, I tried to create a loose and open atmosphere (I offered the participants lunch, sweets and coffee).

Following a brief introduction to my research, I emphasised how different points of view were all valuable, that I had no right or wrong answers, and that disagreements were more than alright. Instead of posing a variety of questions, I sought simply to moderate the conversations, and to interact as little as possible in the discussions. I pre-prepared some broad thematic areas designed to explore 'meanings' related to car driving in general, householders' participation in the intervention, EV-driving, EV adoption, charging behaviour, and sharing experiences etc. Where necessary, I tried to kick-start some discussions by suggesting possible answers. For example, I enquired about what had prompted the test-drivers to join the intervention: 1) having an extra car, 2) to test the latest technology 3) environmental motivations 4) to announce a social statement, or 5) consideration of the future adoption of an EV. However, in most cases the conversation flowed easily, and I did not have to use the follow-up questions that I had prepared. Significantly, I encouraged storytelling from an everyday experiential perspective. To ensure familiarity and recognition with the informants, I concluded the focus groups by asking whether the discussions had proved relevant, and/or whether any other issues of importance had been unexpectedly raised.

Figure 2: Prints of my illustrations of the different 'drivers' of being a 'test-pilot'

The participants in all the three groups were eager to reflect about how they 'made-sense' of EV-driving. Although, none of the households knew each other beforehand, the participants actively engaged in 'small-talk', opening-up the focus-group situation. In accordance with Halkier's useful observations, I also experienced how the formation of meaning occurred in these manufactured spaces of social interaction (Halkier, 2010). Hence, the participants didn't hold back on giving their critical views about their test-driving experiences. The participants were very open about their positive and negative experiences of participating in the intervention. In particular, they were critical about the required commitment of being testpilot, quick-charge stations, and the driving range of EVs.

Overall, there was a high level of consensus amongst the participants. For example, there was generally wide agreement about the meaning of driving, even though the content of the discussions developed throughout the focus group process. The few times that contestation occurred in the conversations, it was typical related to householders' experiences of attempting to adhere to the mobility operator's scripts or due to individuals' contrasting experiences of encountered technological 'bugs'. Interaction within the focus-groups often reflected people's professional positions and, as such, some articulations proved more dominant than others, and consequently determined the agenda to a greater extent than other participants.

Discussions in the focus groups echoed findings from the individual interviews that raised powerful discourses around the freedom, flexibility and individuality offered by conventional driving. Discussions in the groups proved a useful indicator of current norms and reflected societal expectations (shaped by powerful discourses). These salient non-expressions were found to be pivotal in informing householders' experiences of the interventions. In addition, it was very interesting to hear how non-human materials (such as, infrastructure and other domestic technologies) were taken for granted in the participants' discussions. Overall, it became clear that the small focus group forums had potential to create the open atmosphere that I sought in order to encourage informants' honest participation.

Because I changed my analytical framework for my fourth paper, ultimately I didn't analyse the construction of meaning as produced by social interaction between participants. Instead, I used the focus group conversations to explore the paradox of non-adoption, which built upon analytical interests associated with the qualitative semi-structured interviews. I hope to revisit these data, as part of future research, to understand the construction of practice meanings as produced through social encounters.

2.3.4 PARTICIPANT OBSERVATION, BLOGGING AND FIELD NOTES

Figure 3: Photo of the test-pilots over-handing the EVs

Photo: The author's own, 2012

Other empirical data were collected for the case study through my attendance in information meetings connected to handing-over the EVs and one midterm information meetings connected to the combined trial organised by the mobility operator (and partly by the energy company, SE). Besides these meeting providing the opportunity to present my research and meet the participants for the first time, they gave me the opportunity to observe in action; the operator's strategic rationale and tools, explicit rules of trials, and framings of the household participants' role. Furthermore, interactions between the participants and the operator were valuable in exposing explicit and hidden expectations and prejudices – not least how the operator aimed to increase household engagement by encouraging the participants to follow particular scripts and concepts during the demonstration period. The midterm meeting was organised to inform the household participants about the combined trial, and provided details concerned with testing differences between manual *versus* automatic load-management.

As an important part of the demonstration project, participants were obliged to blog on a weekly basis about their experiences and feelings related to being a 'testpilot'. These online descriptions, conversations and activities contributed valuable background insights, however knowledge provided from the blog is not used as primary empirical material in my research papers. All the households I talked to described how they had experienced difficulties in writing interesting blog contributions each week, and writing something that hadn't already been posted on the 'wall'. I reviewed the different blog posts weekly, but reflecting the interviewees' perceptions, the degree of new exciting stories quickly ran out. In parallel, Clever described their frustrations about maintaining participants' enthusiasm for blogging, and how they had contacted the testpilots several times about their obligations to blog on a weekly basis (Interview with Clever project leader, 2013). Clever continually posted news stories about new EV-activities, for example on developments in infrastructure and/or innovation in car models. They also attempted to prompt responses by posting questions about load-management, driving performances, and householders' everyday experiences etc.

Overall, household participants’ multiple perceptions of the challenges and advantages that they encountered everyday gave me comprehensive insight into testpilots’ experiences of using EVs in their everyday lives. The tone used on the blog was generally positive about the opportunity to ‘test-drive’, and indicated how the EVs easily received ‘nicknames’ and quickly became domesticated into the family. During winter, stories about the test EV engine’s low battery capacity and cold engines that took time to warm up, dominated the content of the blogging.

As described previously, I tried to map the households’ descriptions of their ‘doings’ in relation to the technologies, and to diagrammatise the spatial and material organisation of the house, directly after each interview. I also wrote additional notes about the experienced interview atmosphere, and sensory dimensions (noises, smells, household dynamics, heat comfort, lighting etc.), which are difficult to interpret from the transcriptions. This procedure was also applied after the focus group interviews, and proved very useful for recalling the contextualised situations and unarticulated practice elements encountered, which have an important impact in the way that the social situations are interpreted.

2.3.5 ‘RELATIONSHIP’ TO THE CASE

What does it mean for my findings and analysis that my selection of case – and to some extent the testpilots – were more or less predetermined? Due to my partnership with Clever, their smart grid intervention became the subject of my analytical investigation. This also meant that it was essential to maintain a good relationship between the operator and myself (as researcher) to enable continued collaboration. Overall, this ongoing relationship has been constructive and valuable. The company has, from the beginning, been very interested in my research, and has always helped me to understand their intended approach, marketing material and collected datasets. Because I participated in information exchange meetings, and submitted reports of my findings to Clever every six months, I developed a relatively close relationship with the operator. For example, the operator stated their interest in reading my papers before they were submitted to journals, in order to avoid any possible misunderstandings. The operator suggested some changes to my second paper, which I thereafter considered whether to apply or reject. Fortunately, we managed to maintain good cooperation, while I simultaneously retained my critical research approach. This illustrates the classic research dilemma of balancing being a ‘friend’ with the research partners, whilst simultaneously being a ‘critical observer’.

As previously discussed, I acknowledged very early in the research process that the operator suffused TEV with particular techno-rational rationales and incentives, which undoubtly influenced the testdrivers' practices and meanings. Though I attempted to follow my primary interests of exploring the householders' experiences of the interventions, Clever's powerful governance approach and rationales infiltrated my research practice and process. In addition, Clever's framing of the environmental potential of electric driving and their powerful scripting processes, influenced households' interaction with the EV technologies and experiences of static time-of-use pricing, and this important empirical finding influenced my analytical approach. Nevertheless, based on conceptual and analytical framework, I have firmly sought to take a different approach to Clever's smart grid intervention throughout my research process.

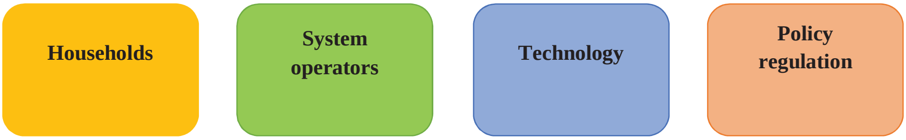
Indeed, if I could have framed my fieldwork from scratch, my case study would have been researched differently. Given the operator's strong influence on households' practices through commitment and because flexibility is user-driven, it could have been useful to have examined testdrivers' consumption and driving performances, based on interventions initiated by the households themselves. From my scientific background in social science and geography, I acknowledge how 'bottom-up' initiated interventions are fundamental for increased engagement and ownership, and hence to achieve sustainable development and change (see contributions from Egmose, 2015; Seyfang & Smith, 2007).

2.4 THE RESEARCH PROCESS AND FINDINGS IN THE FOUR PAPERS

The analysis and arguments in the four research papers are founded on different empirical material and theoretical frameworks within the lens of social practice based approaches. Thus, this journey of knowledge making is influenced by different conceptual and analytical approaches. This is a consequence of the continuous interplay between theoretical and empirical findings within the research process, but also due to the form of a paper-based thesis. The requirements of particular journals and the peer review process has influenced the form and content of the four papers, and presented new analytical frameworks that (to some degree) subsequently re-oriented interpretation of my empirical results. The submitted papers reflect a certain position and temporality within the research design and are, in contrast to chapters within a monography, impossible to update and retrofit. The following introduction to the methodologies and analytical contributions used in this research emphasises knowledge production as a continuously emergent process that has repeatedly opened up new significant questions to explore. The following section aims to clarify this journey and the rationale behind the research design decisions that I took. I introduce the papers chronologically in accordance with their time of submission. Section 6 contains a further discussion of the overall findings of the four papers, including reflections and new perspectives for further research.

The following categories: 'Households', 'System operators', 'Technology' and 'Policy regulation' form the four core analytical foci of the research papers. These categories are useful for providing an overview of the specific analytical framework used within each individual paper. The 'black line' in the figures below (differently sized transparent squares) outlines the point of departure for empirical analysis performed for each respective paper.

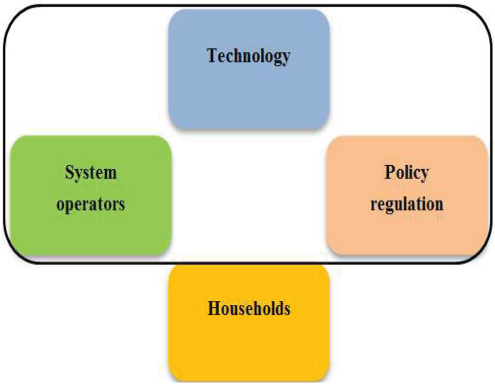
Figure 4: The four overall categories in the papers



The four categories illustrate the analytical framework and empirical foci used in the papers

2.4.1 PAPER I

Figure 5: The analytical framework and empirical framework of paper I

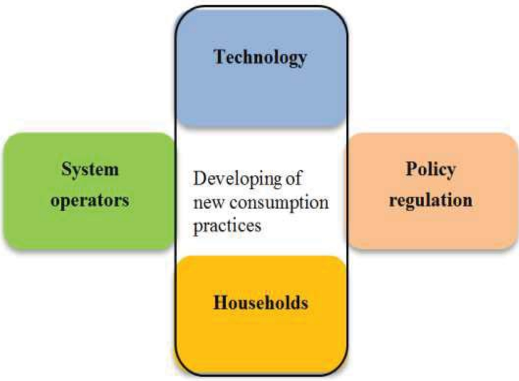


The first paper reviewed R&D within the Danish smart grid discussions and underpinned the lack of knowledge on the household level

The empirical basis for the first paper is underpinned by desk studies of grey literature including; reports of existing smart grid projects, and government white papers. In paper I, we (co-writers were my supervisor Kirsten Gram-Hanssen and co-supervisor Toke Haunstrup Christensen) aimed to review existing knowledge of smart grid interventions, in order to identify research gaps within the field. This paper can be understood as an introductory exercise, and comprises not an equal part of this thesis, compared with the other three papers. First, we demonstrated the very broad conceptualisation of the 'smart grid', and acknowledged how the definition, scope and content are strongly dependent upon country specific factors. Thereafter, focus turned to the variety of research and demonstration (R&D) projects in Denmark and discussed how the majority of Danish smart grid demonstration projects adopt a techno-rational approach to demand-side energy management. Overall, these approaches are based either on; 1) managing demand through intelligent Information and Communication Technologies (ICTs), based on an assumption of passive engagement by household consumers, or 2) managing demand through economic incentives and information provision, which generally emphasised more active consumer engagement. Given growing evidence that such techno-rational approaches are by themselves insufficient to prompt sustainable energy transitions, paper I emphasises how there is a huge risk that smart grid solutions will not work appropriately and under-perform outside of the R&D laboratory. Reflecting the growing socio-technical transition literature, we acknowledge the need to design smart grid solutions according to people's habitual and routinised experiences of everyday life, and recommend more research into understanding households' social practices. Hence, paper I forms the backbone for the three remaining papers.

2.4.2 PAPER II

Figure 6: The analytical framework and empirical framework of paper II



The second paper focused on change and configuration of new consumption practices in the households participating in the combined test-trial (TEV+DNT)

This paper explores the interplay between households' social practices and the smart grid interventions. It examines the information and technological scripts, which were intended to increase demand-side management through leveraging off householders' commitment, and through provision of economic incentives, and information about the potential to save money from time shifting daily practices.

Overall, interview material drawn on this paper endeavoured to gain insight in the households' habits and routines by examining interviewees' daily practice performances, temporal rhythms, and lived experiences of integrating EVs and static time-of-use pricing within their everyday lives. For paper II, my analytical approach was primarily inspired by a practice theory framework, particularly as applied in the area of consumption and sustainability research (Christensen & Røpke, 2005; Shove & Pantzar, 2005; Warde, 2005). The analysis aimed at comprehending; how, and to what extent, households were able to postpone electricity consumption associated with dish-washing, laundry and EV-charging practices, households' experiences of EV-driving performances, and when and how these new consumption patterns influenced and challenged existing household daily routines. Based on Gram-Hanssen's conceptualisation of elements configuring a social practice (Gram-Hanssen, 2011:65) we zoomed in (Nicolini, 2009) on the links and interrelations formed between existing household practices and; 1) new energy consumption patterns and 2) new EV driving practices. The analysis demonstrated how the elements of 'institutionalised knowledge and explicit rules' together with levels of 'engagement', had a significant impact on households' commitment to follow the intervention scripts. Further the analysis illuminated how time shifting created extra 'doings', and led households to have more to remember in the mornings. Also, we found that stress and inconvenience were increased due to technological 'bugs' in the electricity load boxes, and the EVs' limited driving range. Crucially, the inquiry revealed how households' experiences of fun, quick, easy, cheap and green EV test-driving actually increased the performance of car driving and overall led to a replacement of walking and cycling. Further, household experiences of greater comfort related to having an extra car led to articulations about need for a second car in the family.

These findings highlighted some new significant research questions, which called for further investigation. Firstly, it seemed interesting to examine to what degree household participants 'sayings' matched their 'doings'. Or whether there is a difference between people's perception of their levels of household energy consumption and their actual electricity consumption? And further, to explore whether there is a long-term effect associated with participants' increased awareness of the environmental benefits of time shifting their energy-consuming daily practices. This question relates to the 'value-action gap' described by Barr, which called into question dominant assumptions that there is a direct link between interventions in peoples' attitudes, and realised sustainable actions (Barr, 2006). This raised an interest in studying household participants' energy consumption patterns after the trials had ended, and raised significant questions about what characterises 'normal order' and a 'stable' practice (Shove et al., 2012:84,96). Could new energy consumption patterns and driving practices be described as social practices given the relatively short period over which they were performed (during the three-month experimental phase)?

Critically, the analytical work undertaken for paper II had emphasised the importance of the practice element of 'meaning'. Discussion of meanings in practice performances persistently arose in participants' descriptions about their adoption of EVs and their motivation for time shifting particular household routines. Concepts of freedom, flexibility and the importance of individual schedules dominated these descriptions, and I therefore decided to prioritise understanding the construction of these meaning in my empirical analysis.

Therefore, the research process developed based upon my intention to unpack these two aspects in two empirical papers (respectively papers III and IV). The following section depicts how these two lines of enquiry caused some 'dead-ends', and describes how I again came back on 'track'. This section therefore takes the character of an 'Intermezzo' in my research process.

2.4.3 INTERMEZZO: DEAD-ENDS AND 'BACK ON TRACK'

In the beginning, my core intention for paper III was to compare household participants 'sayings' (about their doings) with their actual 'doings', and contribute quantitative empirical-based knowledge about households' temporal performances of electricity consumption practices. This refers to Russell Hitchings paper discussing the challenges of using qualitative interviews to research routine practices (Hitchings, 2012). The partnership agreement with the energy company South Energy (SE) enabled three years of load-profiles (2011, 2012 and 2013) for households participating in the combined trial to be obtained. Overall, these load-profiles confirmed the time shifting attempts and experiences described in the household interviews. The original idea was further to scrutinise these individual 'doings' and compare them with householders' 'sayings', not least amongst participants who had stated that their general awareness of domestic electricity consumption had been increased through their participation in the trial. Further the original intention was to compare the different domestic energy consumption areas of water-use, heating, and lighting. However analysis of the load-profiles proved overly sensitive to spatio-temporal changes such as; variations in household size, changes in daily work times, changes in children's everyday activities (for example, shifts between home and kindergarten), leading to complicated interpretations of load profiles at the individual household level. Moreover it proved impossible to identify specific electricity consumption areas, based on the household load-profiles. Hence, we decided to only use the load-profiles to confirm the relative high time shifting claimed by householder 'sayings', and to compare the average load profiles from 2011, 2012 and 2013 in order to study the persistence of time shifting activities after the test-trial had finished (cf. paper III).

My preliminary intention with paper IV also met some ‘stones on the road’. Based on my initial empirical observations, my aim was to unpack the ‘meaning’ element associated with the performance of EV driving, and to examine the extent to which it is important to consider ‘meanings’ to inform sustainable transition processes. The aim was to explore the discrepancy between the operators’ construction of meaningful and beneficial EV-driving, and the test-drivers’ experiences of EVs as incompatible with their everyday lives. Thus controversies between the operator’s ideal intervention and test-drivers’ experiences and perceptions were to be placed central to my empirical analysis. Originally, the idea was to pursue this question by examining the operator’s powerful discourses about ‘the good life’ of EV driving as veiled in notions of individuality, flexibility and freedom. My analytical framework thus attempted to combine social practice theory with discourse theory. I anticipated that discourse theory would reveal current domestic energy consumption patterns and social norms as constructed through powerful discourses related to ‘meanings’. I presented these thoughts in a paper at the ‘Nordic Environmental Social Science’ Conference (NESS) in 2013, suggesting that idealised sustainability pathways and transition processes reconstruct and reframe ‘meanings’ in peoples’ daily performances of social practices. Further the paper recommended that smart grid interventions should be aware of the powerful neo-liberal discourses that continuously construct ideals about freedom and individuality. Given this, the paper criticised dominant smart grid intervention approaches that attempt to reconstruct individuality, normality and standardisation. At the conference session the framework and ideas received a thorough critique, in particular due to my aim to ascribe ‘meaning’ a higher status than elements of ‘materials’ and ‘competences’, which configure the three elements of social practices according to a ‘Shoveian’ practice approach (cf. section 5.2.1 for a further introduction to practice elements).

On reflection, my intention to focus on the ‘meaning’ element of energy-consuming domestic practices by combining practice theory with social-constructivist and more structure-based discourse perspectives opened up too many conflicting ontologies and rationales. Reviewing my empirical material, I acknowledged the crucial need to tackle power relations, in order to attempt to change the existing organisation and normality of everyday domestic energy-consumption patterns. The actors in my case co-constructed the conventional driving patterns by co-constructing dominant neo-liberal understandings and norms of freedom, flexibility and individuality. Simultaneously, through their storytelling, the testpilots co-constructed certain discourses about what would constitute inappropriate driving (in line with normalised notions of the ‘good life’ of car-driving and home-living). This observation highlights how social practice theories need a more explicit understanding of how power operates through practice to bring about change (or stability) (e.g. Watson, 2012). Thus it became tempting to research questions around the ‘governance’ of practice.

As the backbone of my analysis for developing this ‘meanings’ paper (paper IV), Table 2 was developed to illustrate the different conceptualisations and constructions of meaning in practice, as outlined respectively (and contrastingly) by the operator and the test-drivers. It is notable how the operator’s framing of the advantages of EVs for easing everyday household needs, clashed with the testpilots’ perceptions of the EV-driving challenges that they experienced. Further, both the operator and the testpilots assigned technology and price as core challenges and as the essential solution for future EV adoption, illustrating the role of operators in reproducing (and potentially reconfiguring) current mobility (and energy) demand.

Table 2: The operator’s and test-drivers’ different conceptualisations and constructions of meaning

	Operator’s EV intervention	**Test-drivers’ meaning of EV-driving**
Aim	To increase EV adoption in order to sell charging equipment and protect the electricity grid from peak-loads (by automatic load-management)	To test EVs ability to fit with, and make more manageable, everyday household needs.
Strategy	To collect comprehensive knowledge about the first generation of EVs, and to change people’s mind-sets about normal car-driving through their experience and increased visibility of EVs on the street.	To gain an extra car for free, to test the new EV technology and to care for the environment by reducing household energy demand and vehicle emissions.
Commitment	Involving municipalities to ‘advertise’ and ‘sell’ TEV. Recruiting testpilots to the intervention by signing ‘contracts’ about the household commitment to; use the EV as primary car, undertake weekly blogging, complete daily reporting about driving distances, and participate in advertising campaigns.	In general the testpilots’ were glad about testing the EVs, and happily shared their experiences. Further they intended to follow the rules/scripts outlined by Clever, despite later finding completing the driver-book and weekly blogging too time-demanding. They committed to adopting the load-management intervention, and to using the EVs as the primary car for the household during the test-period.

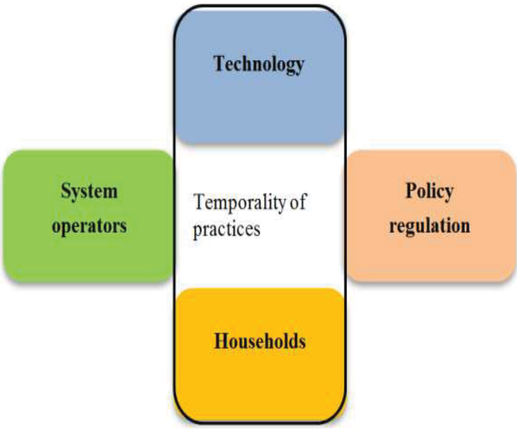
Advantages	The EVs cover 98.9% of daily household needs, and have lower total cost of ownership compared to conventional cars. EVs have huge smart grid potentials when cars are parked and because plugging the car into a power socket at home is easily integrated.	The EVs were perceived to be compatible with everyday life due to their design and acceleration, and were largely experienced as easy to drive. The charging was easily routinised and it proved a relief to avoid the petrol station. In general the testpilots developed a greater awareness of energy-demand reduction and the environment.
Challenges	Gaining financial investment. Core challenges to the limited adoption of EVs in Denmark are assumed to be; a limited number of car models, a limited driving range, and a high purchase price. Future development is considered to be dependent on innovation within the car industry and State regulation of electricity prices and car taxes, as well as investment in charging infrastructure.	None wanted to invest in an EV after the test-period. The general assumptions were in correspondence with the operators: too limited driving range, and too high purchase price. Further the quick charge was too time-demanding and charging infrastructure to insecure. Insecurities due to battery, infrastructure, new technology, the market value etc.
Solutions	To increase technological innovation and development, to develop economic incentives, and to inform consumers of the benefits of EVs.	More R&D and more ambitious policy framing.

As concluded in paper II, households' experiences of 'meaning' had crucial impact for their flexibility in being able to time shift routinised practices. In particular, 'meaning' related to households' 'commitment' to the intervention and their levels of participation, and these in turn reflected the grid operators' pivotal role in attempting to shape demand-side management. As such, the strategies and policy framings of the two interventions certainly merited further analysis. Fortunately, I found a way forward using a 'system of practice' approach, which I was introduced to during my stay as a visiting researcher in the Science, Society and Sustainable (3S) Research Group at University of East Anglia, Norwich, U.K. Through suggestions from my guest supervisor Tom Hargreaves, I gained insight into some of the most recent conceptual developments in practice theory that sought to conceptualise power through practice. During my internship (Spring 2015), I completed a thorough review of dominant perspectives about how smart grid transitions could be realised through widespread EV adoption (see section 4). The review demonstrates how EV adoption approaches are largely dominated by assumptions lying within the techno-rational paradigm, and elucidated a growing openness to contributions from socio-technical systemic approaches that draw on a far broader concept of sustainability energy transitions. Overall, the review found a lack of investigation of how to actually *change* existing unsustainable practices (both within households and as performed by professional practitioners). This finding highlighted the need to bring power and politics to the forefront of my empirical analyses.

In particular, Matt Watson's important conceptual contribution to knowledge that combines ideas from transition theory's 'Multi-Level Perspective' (MLP) (Geels, 2002) with Social Practice Theory, to better account for the demand side of sustainability transitions, became my revised point of entry for further study. This perspective raised the importance of understanding the scope of current 'systems of practice' aligned perspectives for enabling sustainability transitions (see reflections from (Shove et al., 2015; Spurling & McMeekin, 2014; Watson, 2012). This research focus formed the basis for the framework described in paper IV. Applying a 'systems of practice' based approach to my research, emphasised the importance of researching how (if at all) smart grid operators acknowledge, and seek to intervene in, the interrelations between social practices.

2.4.4 PAPER III

Figure 7: The analytical framework and empirical framework of paper III

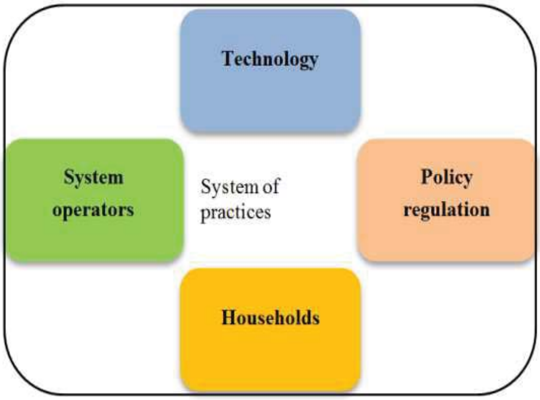


The third paper focused on the interconnectedness between time shifting and new 'temporality of

Based upon the analysis (as described in Paper II) of householders' apparent ability to postpone their electricity consumption by integrating new configurations of practice elements and new relations between practices, inquiry for paper III focused on the recursive relationship between domestic practices and temporalities of everyday life. Taking into account several researchers' warnings against being too optimistic about the potential to time shift households' electricity consumption (Nicholls & Strengers, 2015; Powells et al., 2014; Southerton, 2012; Walker, 2014), this framework additionally recognised the complexity associated with changing the 'temporality of practices' at household level. As opposed to mainstream intervention approaches that understand this flexibility as a matter of changing individuals' attitudes, behaviour and choices (Shove, 2010b), paper III considers time shifting as a matter of peoples' flexibility in being able to restructure the collective temporalities of currently performed practices. The time shifting of households' electricity-consuming practices, synchronous with intermittent electricity generation, introduced new coupling constraints. These constraints challenged the householders' ability to flexibly control the temporal organisation of their daily practices. Examining households' 'sayings' demonstrated how new constraints associated with EV-charging and time shifting complicated the performance of interrelated systemic practices. This reconfiguration often increased householders' feelings of 'harriedness' (Southerton, 2003) due to the required extra doings associated with running an EV, and having more things to remember due to a change in the temporal organisation of routinised practices. Use of the concepts of 'hot spots' and 'cold spots' (Southerton, 2003) illustrated how domestic habits and routines are constrained by collective institutional rhythms – not least how social togetherness around the breakfast table is a highly valued activity associated with 'cold spots'. This observation highlighted how future demand-side management strategies need to be aware of the complexity of practice sequences. The feeling of harriedness caused by inconvenient breaks in habits and routines is closely associated with a loss of control over the temporal organisation of daily practices. This is underpinned by how convenience is associated with having control over the temporal organisation of one's activities. Moreover, this research demonstrated how flexibility to time shifting is also dependent upon householders' personal dispositions (Southerton, 2012). Whereas some households were aware of economic incentives to save money on household electricity bills, others stated that their commitment to the intervention scripts formed the core explanation behind their ability to time shift their practices.

2.4.5 PAPER IV

Figure 8: The analytical framework and empirical framework of paper IV



The four paper illuminates how EV driving is interrelated in system of practices

Paper IV 'zoomed out' (Nicolini, 2009) to examine how smart grid interventions need to attempt to reconfigure existing 'system of practices' in order to achieve lasting sustainable energy transitions. Evaluating the operators' framing of 'EV-driving-as-entity' (Shove et al., 20128,48) confirmed their dominant focus on technological innovation as a means to achieve sustainable energy transitions. The operator assumed large-scale EV adoption would occur with improvements to battery capacity, more EV car models, and a reduced purchase price. As such, the operator reinforced the dominant techno-rational paradigm that is concerned with encouraging smart grid development and decarbonisation through technological fixes and changing people's rational mind-sets.

To strengthen this point, I focused my literature review on EV adoption, and took into consideration the different theoretical frames of transition that would inform mass adoption of this anticipated smart grid technology. I found that in general intervention approaches based on EV adoption, were found to involve limited user innovation and participation. This overarching position collided with TEV's strong participatory and knowledge-producing strategy. For example, the operator attempted to encourage testdrivers' involvement through several different approaches and 'rules'. My empirical data analysis illustrated that the operators' framing of householder engagement in the intervention, conflicted with the test-drivers' experiences of meaningful driving, and this mismatch crucially reproduced and reinforced conventional resource-intensive driving amongst the participants.

The second part of my analysis for paper IV explains the paradox of non-adoption, as reproduced by existing institutional arrangements and infrastructures. This analysis draws mainly upon interviews with the winter testdrivers who were not exposed to variable pricing (i.e. focus groups), because perceptions of non-adoption were significant amongst this group. In addition, this empirical material highlighted several unforeseen side-effects. In addition to the side-effects of participating households increasing their driving practices at the expense of cycling and walking, and their experiences of EV testing reinforcing the need for a second car, these households recharged the EVs when they returned home from work in the early evening, coinciding with the peak load occurring between 17:00 and 19:00. This finding critically challenged the assumption of households as innovative grid operators in the smart electricity system. Furthermore, the winter test-drivers declared that they began to use electric heaters during the winter mornings. These examples emphasise the unintended and unsustainable consequences of mainstream techno-rational approaches, and crucially highlight why an alternative 'systems of practice' approach is essential for achieving lasting sustainable energy transitions (cf. paper IV).

Considering (EV) driving as interlocked within broader systems of practices reinforced the need for future mobility interventions to understand why, and potentially change how, interconnected practices become linked together or overlap. Paper IV recommends that mobility interventions seek to understand, and potentially change, intersections between driving and other associated practices, and further bring 'negotiability of need' for driving (Shove & Walker, 2014) onto the political agenda. Hence, those governing policy interventions and mobility operators (such as Clever) need to recognise and map in order to intervene the powerful systems of practice of which driving forms a part. To enable lasting sustainability transitions, they also need to encourage the reconfiguration of driving practices (and associated practices, as appropriate), in order to influence cultural meanings and norms that gather around particular sets of technologies (such as cars) and introduced innovations affecting these technologies.

Table 3: Overview of different methodological approaches, when and where data collection and analysis were conducted and interpretation of these results across the four papers

Methods	Time & Space	Analysis and Papers
Individual semi-structured interviews with households.	Summer time (2012), detached houses located in the outskirts of two middle-sized cities in the South of Jutland. Participation in the combined trial that ran over five months (DNT + TEV).	Analysis of 'sayings and doings' to illuminate the reproduction and change of the temporality of everyday social practices focusing on the expected potential 'flexible' consumption practices related to laundering, dish-washing and EV-charging . General insight into the interplay (challenges and advantages) between adopted smart grid technologies and everyday household practices. Paper II, Paper III
Individual semi-structured interviews with 'professional practitioners'.	Conducted in Clever's meeting rooms and in the offices of the Danish Transport Authority (2013).	Analysis of the operator's and funder's dominant assumptions of change, strategic instruments, and experiments. Analysis of the interplay (challenges and advantages) between adopted smart grid technologies and everyday household practices related to driving and the potential 'flexible' consumption practices related to laundering, dish-washing and EV-charging. Paper IV
Focus group interviews with households.	Winter (2013) conducted at the testpilots' work-places – hospitals in Herlev and Copenhagen. Participation in TEV over a three-month period during the winter 2013.	Analysis of the 'meaning' ascribed to 'test-driving' by participating households. Analysis of the interplay (challenges and advantages) between smart grid technologies and everyday household practices focusing on driving practices. Paper IV
Participant observation, test-drivers weekly blogs, field notes, and email correspondence with Clever.	Attendance at the EV 'hand-overs' and 'hand-ins', information meetings, and observation of the weekly activities, regularly through 2012-2015.	Background knowledge informing all research analysis. Paper I, II, III and IV.
Quantitative	Review of electricity	Analysis of the testpilots' load-profiles of

data material comprising load profiles.	consumption data from housholds participating in the combined trial (2011, 2012, 2013).	daily household electricity consumption before, during, and after participation in the combined trial. Paper III
Policy documents, white papers and a review of existing smart grid projects.	Review of smart grid projects to identify the current dominant vision of ‘smart’. Completed in 2012.	Analysing the gaps within the current smart grid projects and identified the need for gaining knowledge on households’ social practices. Paper I
Literature review of EV adoption.	The review gave an overview and insight in the dominant approaches within EV-adoption in research and development. Completed during my stay at UEA (Spring, 2015).	Reviewing literature in a variety of research and policy. This included a review of respectively different research strands within the EV-adoption field and international and national policy strategies outlined in documents and reports.

3. INTRODUCTION TO THE CASE STUDY

Translation: "Here is the extra equipment you need to bring with you when you buy an electric vehicle. A lab coat and a halo…" The cartoon was drawn by the cartoonists Mikael Wulff and Anders Morgenthaler also known as 'Wulffmorgenthaler' in 2015

Due to the limited space provided by an academic paper, this section unpacks the operator's aim, strategy and rationale. This thorough introduction to the case study intervention is derived from interviews with the project leader, project coordinator, and the funder from the Transport Authority. As far as possible I purposely avoid including normative judgements, and thus postpone critical analytical views until later discussion (cf. section 6). Following this introduction, I describe the technical 'bugs' present in the load boxes and reflect on what these technological deficiencies meant for the project results. Finally, I briefly reflect upon the implications associated with studying a technology that has undergone substantial innovation since the commencement of this research project (i.e. EVs).

3.1 DESCRIPTION OF THE INTERVENTION

The goal of the TEV intervention was to test the first generation of mass-produced electric vehicles (EVs) amongst a variety of Danish households living in different parts of the country between 2011 and 2014. Framed as the most ambitious demonstration project in Northern Europe (Clever's final report, 2014), the operator (Clever) gave the first round of test-drivers the keys to their brand new (factory-produced) EVs in September 2010. In May 2014, 198 EVs were tested in 24 municipalities by 1,578 test-households over the course of three months, which according to Clever's estimations resulted in 4 million driven kilometres and prevented approximately 315 tonnes of carbon dioxide emissions in total (Clever's final report, 2014). The demonstration project delivered a variety of data on EVs' operational reliability, charging patterns, and household driving needs, and thus contributed comprehensive understanding about the energy potentials and challenges associated with EVs (Clever's final report, 2014). TEV's overall aim was to obtain insight into how EVs are adopted and integrated into Danish households' everyday lives. Consequently, the original vision for the intervention was to change the general assumption of EVs among the Danes to ensure that the EV becomes a part of their choice of vehicle in the future, in order to benefit the environment and energy production (Clever's refunding application, 2011:3). Further, the intervention was designed to explore EVs competitiveness compared to conventional combustion cars (Clever's final report, 2014).

Significantly, the user-based data produced by TEV has proven a pivotal means to develop Clever's long-term business strategy. Indeed, TEV was the foundation for developing the commercial basis for the company, as the project coordinator stressed:

> "We are a company founded on user experiences. Hence, we base our products on users' input. Unlike BetterPlace [rival company at that time] who intervene with an already finished product, we focus on user innovation. TEV is a development project and our company [was] started [based] upon that project. We listen to users and create a product that suits their needs" (Project coordinator, 2013).

As demonstrated in my analysis (cf. paper IV) Clever's extent of 'listening' to their customers and user-driven innovation seemed fairly limited. Though, compared with the approach of 'BetterPlace', which was the company's competitor at that time and focused solely on major technological investment, Clever's strategy seemed progressive due to the priority of collecting data from users' experiences. In addition, Betterplace and TEV had different strategies to solve the problem of limited battery capacity and the time required to recharge the battery. Betterplace developed a design with switchable batteries, which meant that the batteries could be conventionally charged at home or at work, or could be replaced with fully-charged batteries at 'battery swich stations' which took around five minutes (like filling the car with petrol). In contrast, Clever approach this charging problem by building up a network of 'quick charge stations' across Denmark. A quick charge took around 20-30 minutes (a normal recharge typically takes 5-6 hours). Many of the charge stations were located near supermarkets or proximal to other locations where you could spend some time. However, Betterplace declared bankruptcy in Spring 2013 due to failing car sales. Given the low sales rate of EVs, Clever decided to abandon the EV sales strategy and focus on installing public and private smart equipment to manage users' electricity consumption in order to safely operate the electric grid.

In June 2012, Clever inaugurated a nation-wide EV charging network, which was supplied with charging ports and quick charge stations that were suitable for a variety of EVs. Today (2016) Clever's network comprises, as many as, 500 quick charging stations in Denmark Sweden and Germany (www.clever.dk). As a private enterprise, owned by five Danish utility companies SEAS-NVE, SE, NRGi, EnergiMidt and Energi Fyn, Clever's project leader described the company's business strategy as:

> "Clever's ultimate aim is to create a long-term investment for the energy companies. Regard it, as a kind of 'transfer payment'. Along the way we will adapt our model completely to prioritise the energy companies' interests. Thus, Clever's overall goal is to get behind the power outlet and to control the charging proces. You might see it that 'we are the electric car's range-extender supporting all EVs'. So we partly work to optimise the infrastructure by installing charging stations in the right places, and partly to convince companies about EVs as a good solution, in terms of economic savings and [building] a greener profile" (Project leader, 2013).

In addition, the project coordinator stressed:

> "We have been the 'clever' in the class room by starting [the business] up quietly" (Project coordinator, 2013).

Despite TEV, in part, forming a strategic instrument for pursuing Clever's commercial business strategy, the demonstration project distinguished itself from purely corporate profit-making interests probably due to settings outlined from the public foundation. TEV's aim was to generate analytical data that could help to develop and understand sustainable smart grid solutions over the long-term:

> "TEV is not a sales promotion project. It is a behaviour project. It is an investigation of the behaviour around the EV. Clever collects this knowledge and operationalises it in further marketing development. The long-term vision for Clever is to convince the Danish population that the

> EV actual works (…). From the beginning we knew it works [EVs]. Now we just need some arguments for why it [EVs] works, strengthened by actual facts, while we simultaneously must promote that it works to customers and the general population" (Project leader, 2013).

The assumption for TEV, was that knowledge about EVs' attributes, advantages, and limitations would enable the operator to effectively manage smart grid potentials according 'peak-shaving' and 'storing' activities (Danish Transport Authority, 2014; Clever's final report, 2014).

Apart from Clever's own funding and sponsorships from private companies, TEV received public financial support from several municipalities, and respectively from the Ministerial departments: Danish Transport Authority and Danish Energy Agency. The Transport Authority's reasons for supporting the project (with approximately 2.8 million EUR) were to promote solutions that would reduce transport generated carbon emissions and to facilitate implementation of energy-efficient transportation. The Energy Agency (supported with approximately 0.8 million EUR) wanted to gain concrete knowledge about the infrastructure that would be required on the basis of EVs' peak-shave and storing potentials (Clever's final report, 2014:5; Danish Transport Authority, 2012:1). Significantly, TEV was carried out in a political reality that was characterised by the Danish Government's target to be independent of fossil fuels by 2050, and their associated vision for the nation to accomplish 50% renewable energy levels by 2025. EVs were expected to be one of the smart grid solutions that would help mitigate climate change due to EV batteries' capacity to replace fossil fuels with renewable energy sources (Danish Government, 2013a). As such, significant political instruments were introduced to stimulate EV-market penetration. These included; EVs being made exempt from registration, weight, and owner tax in 2013-2015 (Registration Tax Law, 2014), and politically enabling demonstration projects that would give EV-owners a discount on the electricity consumption expenses related to recharging.

This comprehensive empirical data collection was intended to 'eradicate' the negative bias and prejudices that Clever perceived had formed around EV technology (for example, that EVs are insecure, more expensive, limitations related to driving range and challenges associated with charging etc.). While the 'hard' data (logged data on driving date, time, distance, battery capacity) provided knowledge on the engines' ability to make valuable forecasts about fuel consumption, load patterns, driving performance and range extension, the 'soft' data (test-drivers' personal reflections, number of passengers, households' driving targets, and participants' daily blog contributions) - primarily collected from the driving books and the blog - crucially increased understandings of the test-drivers' everyday compatibility with EVs. TEV was expected to verify 36 different hypotheses designed to convince households about the EVs ability to meet their daily driving needs. In particular, Clever wanted to encourage adoption by highlighting the environmental and financial benefits associated with EVs. The participatory experiment was considered to be a significant strategical instrument in promoting the performance of EVs and their suitability in covering everyday household transportation needs. The following quote illustrates how strong user involvement was advocated as a pivotal pre-condition for attempts to change consumers' mind-sets about EVs:

> "The project's value with respect to changing attitudes amongst private people and industry is completely unique (…). The project is 100% user-controlled, which generates positive publicity, and this massive exposure is of great value for the promotion of EVs (…)" (Clever's refunding application, 2011)

As such, the project's success criterion was to test EVs among a variety of consumer households from all over Denmark, and to introduce EVs to the public sector.

Figure 9: The first generation of mass-produced EVs before they were handed-over to the test-drivers

Photo: Clever. The permission for publishing has been given from Clever

Both private and public actors (24 municipalities, 3 hospitals, 5 private companies) were enlisted as crucial fundraisers, facilitators and partners for securing local backing of the project. These actors were pivotal for recruiting testpilots from across the country. While running the project, additional private companies wanted to participate, but due to the public financial support, TEV was not allowed to give private companies subsidies connected to EVs. As a compromise, the project administrators decided to permit interested private employees to become test-drivers, which enabled a continued project focus on the end-user. The municipalities were considered as 'gate-keepers' that would anchor and validate the project, and they supported TEV with financial support, advertisement and practicalities related to the handover and delivery of the EVs. To further legitimise the safety and security of the project, the largest Danish interest group for private car owners (FDM) and the security company (Falck), were also important partners in the project.

The recruitment of test-drivers was carried out by public announcements by the municipalities and an advertisement on Clever's homepage. However, 'snowball sampling' proved to be one of the most valuable methods of recruitment, as the project leader described:

> "We've got several examples of family members and friends that applied to be testpilots. Actually, we have seen neighbours testing EVs one after the other, without our involvement. This is funny" (Project leader, 2013).

However in order to avoid too many of what Clever called 'free-riders', the test-drivers were phoned and interviewed about their motivation for participation. The following quote illustrates TEV's attempts to achieve a broad cross-section of participants:

> "We had no interests in recruiting more engineers or environmental enthusiasts. In contrast, we sometimes chose applicants with a critical outlook towards the project" (Project leader, 2013).

In addition, the project coordinator stressed:

> "The study is of course representative. We have selected testpilots of different ages, women and men equally, those with different driving needs – some drive 0-20km per day, others drive 20-40km and others drive over 60km per day, also income and education have been important selection criteria. In general, the EVs have been broadly tested" (Project coordinator, 2013).

In this way, TEV attempted to collect EV driving experiences from a broad cross-section of households living in different contexts. Consequently, the project leader stressed that the selection of testpilots (test-drivers) had been objective, whereby anyone was open to being a testpilot, as long as particular requirements within the application form were fulfilled; such as having a driving license, a willingness to pay the electricity costs related to private charging, ownership of a car in advance, and living in a detached house within one of the 'test' municipalities. Further, the funder also sought out participants from rural areas requiring longer driving distances, in order to gain experiences about driving EVs when their battery capacity was more challenged. By signing the project contract, testpilots committed to: using the EV as their primary car (to prevent increased motoring and associated emissions); paying any extra expenses associated with the household electricity bill; weekly blogging; filling-out the driving log-book; participating in public events; and completing questionnaires. Further, the testpilots were encouraged to load the EVs during the night, using the quick-charge stations (for free), and to tell others in their social networks about their EV driving experiences.

Analysis from the data-loggers (interpreted the Technical University of Denmark) showed that overall the EVs driving range covered 98.9% of the testpilots driving needs. In addition, final evaluation of the TEV outcomes was able to verify the hypotheses that; EVs are secure to operate, have lower Total Cost of Ownership (TCO), enable cheaper maintenance and service costs compared to conventional combustion cars (42-54% lower), have significant smart grid potential because EVs remain sedentary for many hours per day (70% of all recharging took place on the home address). Further, visibility due to the dissemination of EVs on the road was confirmed as an extremely valuable factor for changing peoples' mind-sets more favourably towards EVs. Overall therefore, Clever's project leader expressed satisfaction about the outcomes of TEV;

> "We demonstrated that the EVs worked. We had a lot of positive feedback, some points of criticism, but generally TEV has been a success (…). We've dismantled several myths and challenged prejudices which are superb, since that was the primary aim of the project" (Project leader, 2013).

As noted, Clever's expectations were that test-drivers would change their sceptical mind-sets by testing the EV technology in practice, and that their experiences (which were assumed to be positive) would increase the potential of smart grid demand-side management in the future. Whilst TEV delivered successful results and positive user experiences regarding EVs' attributes and performance, paradoxically none of the test-drivers were keen to adopt an EV after participation in the trial. In other words, the tested first generation of EVs didn't make sense as a household vehicle and electric vehicle driving was not embraced as an ongoing daily practice. The operator explained how, in his opinion, this paradox was caused by a mental barrier, which is touched upon in the following:

> "I don't see any problems related to integrating it [EVs]. So, there are few good arguments for non-adoption. It is also cheaper, once you have

> bought the EV, to drive it. Our calculation, which can be found on our website, shows actually that EVs' operating costs over a five year period are cheaper than for an equivalent petrol car, but the economy [purchase price] is obviously a barrier, and another barrier is the mental or psychological one, related to fears about driving range" (Project leader, 2013).

The operator recognised the need for clarification about the EV technology in order to eliminate potential consumers' doubts. Uncertainty is mainly related to unpredictable future scenarios, such as purchase price, market value, public incentives, battery capacity, running and maintenance costs, electricity prices etc. In light of these uncertainties, the operator acknowledged the need to attempt to influence householders' mind-set around EV ownership and (potentially more favourable) leasing options. Additionally, the project coordinator underpinned the challenge of car ownership referring to the test-drivers' blog entries:

> "[t]here are plenty of flexible leasing opportunities, but people ask often 'what are the costs and what is the purchase price? People are much focused on ownership" (Project coordinator, 2013).

Overall, Clever anticipated that the State and the car industry would form core drivers to the future adoption of EVs by the Danish population. Hence, the car manufacturing industry was expected to increase the competitiveness of EVs by developing the technology, whereas the State was considered to be accountable for the regulation of taxes on cars and electricity usage. In relation to this, the operator highlighted that taxes on EVs and the absence of a legal basis for differentiating between electricity prices, were the core challenges for future intervention. At Clever's final conference (June 2014) the general expectation among Clever, the Ministries and actors related to the car industry was that EV adoption would increase as soon as the car industry releases new models to the market, providing consumers with a wider selection of EVs. This causation was further clarified by the funder:

> "It [EV adoption] has proceeded at a much slower pace than [Clever] expected. The selection of vehicles must be greater. The range is too limited. It's a clear limitation. But here in 2014 we've got more models from Renault and Volkswagen (…). People are going to demand more, when there is a greater supply, then it will be more likely that there's a car that suits them" (Funder, 2013).

In addition, the project coordinator expressed the following about (s)low adoption:

> "We can't do anything about it. We're so dependent on car manufacturers' products. But essentially it [greater adoption] requires more attractive products" (Project coordinator, 2013).

Thus the general assumption by the funder and project backers was that within a few years of R&D the limited selection of models and the problems related to battery capacity would be resolved.

According to the European Union's (EU) increased legislation on carbon dioxide emissions reduction, car manufacturers are required to produce a certain amount of low-carbon vehicles in order to continue the production of conventional high-emitting combustion cars. As such, the car manufacturing industry's real reason behind investing in R&D around EVs, relates primarily to producing 'compliance cars'. In the following quotation, this concern is clarified;

> "If they [car manufacturing industry] really want to sell any of these [vehicles], they must accept a loss, due to EVs' more expensive production costs. I question whether the industry is really attempting to accommodate climate change, or whether they are just obeying the EU's requirements in order to avoid fines (…). One day the oil industry says that they would like to invest in EVs, but the following day they criticise EVs" (Project leader, 2013).

Referring to the EU requirements, the funder similarly elaborated;

> "Yes, the car manufacturers are a bit lukewarm (…). For car manufacturers it's an average of 130g CO2 per km, and when EVs are ascribed 0g CO2 per km, the incentive to sell a few EVs increases their opportunity to earn a lot of money from the sale of huge combustion cars (…)" (Funder, 2013).

As illuminated in the literature review (cf. section 4), the latest EU standard determines that cars may emit a maximum of 95g CO_2 per km by 2021, which Clever expect will have a huge influence on the car industry's prioritisation of R&D in EVs (meeting held with Clever's Head of Communication, 8th of March 2016).

3.2 BUGS IN TECHNOLOGY

As previous mentioned my first sample of testpilots participated in the combined trial (TEV + DNT). Further than testing increasing incentives, the electric mobility operator wanted to test the difference between two ways of performing EV battery charging; manual load management, and automated load management controlled by the operator. Midway through the test-period Clever started to control the load-management automatically. Hence, the households had to programme the EV charging timers, and the operator controlled the charging and guaranteed the cheapest price on electricity. Clever’s final results indicated, as supported by my qualitative interviews, that the households preferred automated load-management, as opposed to individually self-programming the timers. My qualitative interviews crucially revealed that all the participants experienced technical ‘bugs’ in the load boxes related to programme the timers, which contributed to a high feeling of uncertainty. Consequently, without exception, the participants manually plugged in the load-cable before going to sleep. Though, the interviews show that this practice was easily routinised, because the participants coupled this ‘plug-in-to-charge’ practice with the ‘shutting-down-the-home-before-going-to-bed’ practice. The bugs in the load boxes were also experienced amongst participants in the focus groups interviews, and thus seemed to be a general problem across the demonstration project.

Clever’s final report of TEV concluded that the testpilots mainly charged their vehicles during the peak hours between 15pm and 20pm, providing that there were no spectacular economic incentives to time shift. Referring to the ‘test-families’ (families who participated in the combined trial) the report emphasised:

> “just prospects of making financial savings means that people are willing to move their charging times (…) and that variable prices affect their way of consuming electricity (…). They should save between 500-2000kr. per year before they are willing to move the timings of their electricity consumption” (Clever’s final report, 2014).

In general, in light of my empirical results, I found it difficult to draw such conclusions due to the technical deficiencies in the load boxes, installed by Clever. These faults related to household difficulties in programming the timers and their very stressful experiences of encountering empty batteries during hectic mornings. Rather the households’ failure to postpone vehicle charging times, in my view, indicates the fact that the technology did not work in practice (as it was the first version of development). This corresponds with Actor Network Theory’s perspective that technologies and materials hold a high ontological status and impact on (and are influenced by) the structure of social life (this perspective is further elaborated in section 4.6.2).

3.3 STUDYING AN OLD TECHNOLOGY

Figure 10: The image in the top illustrates the tested EV model from TEV, whereas the bottom image is one of the newest models

Photos: Clever. The permission for publishing has been given from Clever

Since I started my PhD research on smart grid technologies in 2012 (I went on maternity leave September 2013 to October 2014), EV technologies have undergone substantial advancements in research and development (R&D). In regard to my analytical focus, due to this constantly shifting stage, I have been very clear to focus my attention on integrating the smart grid technologies that were to be integrated as part of the TEV trial. However due to my ontological scientific approach (for which, technology forms a crucial part of everyday practices), the technological aspects of the tested EVs are also acknowledged as pivotal for adoption. During the research process, the recursive relationship between technological and sociological aspects of EV driving continuously appeared. For example, the participants' development of new driving patterns and increased consciousness of electricity consumption, were related to the battery's high efficiency for acceleration as well as their sensitivity to weather conditions and particular more electricity-demanding driving practices. This interaction increased the incentives for householders' to develop greener driving techniques, particularly amongst the winter test-pilots.

Whilst I have explained my reasons for concentrating on a particular EV type and stage of development (as specified by the TEV trial) section 4.4.2 reviews some of the most important technological innovations, 'critical events' and trends related to EV adoption within the recent years. The following section builds on this review, and draws comparisons with state-of-the-art EVs being developed in 2016.

As previous noted, the TEV demonstration project involved the first generation of mass-produced EVs, testing different models including; Mitsubishi iMiev, Peugeot Ion, Citroën C-Zero and Nissan LEAF. The first three models, called ‘The Twins’ due to their identical technology, were small family cars with an average driving range of 150km (with a full battery). The Nissan LEAF is a middle-sized car, which is able to be driven 175km on a full battery. The calculations of expected driving range depend highly on driving patterns, which is why the EVs’ driving range is typically lower in practice (as for conventional cars). In contrast to conventional cars however, EVs’ fuel efficiency is particularly good for city driving, whereas the range drops significantly with faster highway driving, especially if heating and air-conditioning are turned on. EVs have a high efficiency for acceleration (using far less power compared to conventional cars), but the batteries are simultaneously much more sensitive to external forces, for example detrimental weather conditions, and use of electricity consumption (aircondition and radio) while driving (Danish Transport Authority, 2012). This corresponds with my interviewees’ declarations that they try to adopt less energy-intensive (and more climate friendly) driving techniques and maintain increased awareness of their levels of fuel consumption whilst EV driving.

Since 2011, the EV technology has undergone massive technological innovation. In particular, parameters such as safety and security, design, comfort and ‘nice-to-have’ gadgets have been significant upgraded. Parameters such as driving range and electricity consumption have also significantly advanced. It is important to underscore that the Nissan LEAF (one of the tested EVs studied in this research), is still the most widely sold electric car at a global level (www.elbilsupport.dk). Nevertheless, due to a recent focus on developing and advancing EVs (in terms of; increasing size, extending driving range, and improving battery capacity) mean that the first generation of EVs, that I studied, will soon become a ‘thing’ of the past. Today, several EVs have a driving range of approximately 175km, and in particular the newest models from Tesla have a driving range of up to 470km. Notably, the average purchase price of a Teslas is still multiple times higher than conventional EVs, but this EV capably competes with similar combustion cars in the luxury car class. This indicates that some of the concerns associated with EV driving are being addressed and solved. This said, the price of EV vehicles is still high, and the timings of domestic electricity use largely continue to follow the same routines demonstrated by this thesis. The following section contains a comprehensive introduction to EV adoption in terms of ongoing research and development (R&D) and the evolving policy landscape.

4. REVIEW OF EV ADOPTION

4.1 INTRODUCTION

This section contains a general introduction to EV adoption respectively from a historical, political and theoretical perspective. In order to obtain an overview of the field, the aim was to identify mainstream trends and dominant assumptions influencing widespread EV adoption. Like the review of smart grid development in Denmark (Paper I), this overview of policy and research approaches highlights dominant techno-rational solutions for EV adoption. These approaches attempt to boost the market expansion of EVs by underlining economic incentives and technological innovations as significant instruments for promoting this agenda. In addition, core targets of subnational and national governance agendas are to make EVs competitive with conventional cars by supporting financial instruments, substantial technological investment, and not least educating consumers to ‘go electric’ through widespread information campaigns. These approaches align with dominant attempts to technologically-fix climate challenges.

In converse to these general trends, growing research emphasises a need for a deeper understanding of change that combines both technological and sociological aspects. These socio-technological perspectives acknowledge how EV adoption is constructed by both social and technological developments, and warn of future interventions that adopt solely a techno-rational governance approach. Instead of concentrating on individuals’ attitudes, values and behaviours and their immediate contexts, socio-technological approaches adopt a broader approach to change by acknowledging the complexity of the seamless interactions occurring between technology and society. Further, the dominance of techno-rational approaches for the deployment of EVs, underscores the need for interventions for establishing a less energy-intensive society to recognise that all social life is made up of bundles of social practices that are carried out and performed by practitioners across time and space. Hence, this introduction to the EV field provides a stepping-stone to the following extended presentation of social practice theory as the analytical backbone of the thesis (cf. section 5).

4.2 METHODOLOGY

The term ‘EV adoption’ covers comparable synonyms such as EV invention, EV diffusion, consumer acceptance of EVs, and infrastructural transitions towards electric transportation etc. Consequently, EV adoption relates to the current powerful discourse on electrifying contemporary transport systems, which is considered as an inevitable ‘future scenario’ for reducing societal dependence on unsustainable fossil fuels. During the process of data collection, I entered keywords – such as, electric vehicles (EVs) and/or other terms referring to rechargeable cars and consumer responses to these technologies – into different search machines (Google Scholar, SCOPUS, EBSCO and J-store). For example, a sample research string might comprise ‘EVs AND consumer adoption’ or ‘Electric cars AND diffusion’. In particular, I concentrated on review papers, which were analysed in-depth. Importantly this review uses the term EVs, to refer to cars with batteries that can be charged from an electricity outlet and therefore they require the ‘plug-in of the car into the grid for charging’[1], which differs from alternative hybrid electric vehicles and hydrogen fuel cell vehicles. The selection of literature primarily focuses on studies dated from 2005 to 2015 – when research on consumer adoption and EV mobility within the smart grid increased (as quantified using the SCOPUS database). Analysis illustrates a variety of different epistemological and ontological approaches for understanding the diffusion and adoption of EVs as a smart technology. To structure the analysis, the 100 plus articles were divided into different – heterogeneous and overlapping – research categories. These six analytical categories were respectively:

Table 4: Categories articles reviewed on EV adoption

Categories	**Articles reviewed (total)**
Government incentives and regulation	12
Demonstration projects	7
Review articles	16
Psychological approaches	8
Techno-rational approaches (focusing on technology design, economic incentives, and marketing strategies)	49
Socio-technological approaches	10

Table 4 demonstrates how the majority of available research articles reviewed was based upon techno-rational approaches. Overall, this *corpus* of research aims to predict future EV adoption by determining levels of technological innovation and investment, and modelling individuals’ willingness and readiness to accept EVs. Psychological approaches tend to focus on consumers’ cognitive preferences and behavioural intentions to invest in EVs. Within the socio-technical approaches, contributions from the Multi-Level Perspective (MLP) for socio-technical

[1] Note that plug-in hybrid electrical vehicles (PHEVs) belong to the general term EVs.

transitions account for the majority of articles, however some studies draw on actor-network theory perspectives. Only one study is based on a social practice theoretical approach. All analysed studies were (more or less) empirically based, with the exception of the review articles.

4.3 EVS IN THE 21ST CENTURY

The 'side-effects' of conventional petrol or diesel fuelled cars with internal combustion engines (referred to as 'conventional cars'), alternative vehicle technologies as hybrid electrical vehicles (HEVs), plug-in hybrid vehicles (PHEVs) and electric vehicles (EVs), have emerged due to recent advancements in technology, making electric driving technically and commercially possible. Globally, EVs are expected to be a crucial technology for decarbonising transport systems and reducing the world's dependence on fossil fuels and greenhouse gas emissions, due to their potential to operate using electricity from renewable energy sources and their ability to balance supply and demand in the energy system by storing electricity in their batteries (Bakker & Farla, 2015; Bradley & Frank, 2009; Dijk et al., 2013; Richardson, 2013; Sierzchula et al., 2012). Climate change abatement strategies tend to reduce urban carbon emissions through electrification of the existing transport sector. This has led to an urgent need for research to help understand how mass-adoption of EVs can be obtained. In this regard, consumers' acceptance and willingness to adopt EVs appears crucial in order to 'release' EVs anticipated smart grid potential.

4.3.1 A (RE)EMERGING TECHNOLOGY

The history of innovation in automobility has often shifted from one alternative fuel to the other, a phenomenon known as 'fuel du jour' syndrome (Sperling & Gordon, 2009). EVs are an example of a technology that has gained momentum several times, without turning into mass production and adoption. These developmental phases can be understood respectively as: Early days, Midterm and Present (Situ, 2009). Researchers often describe the evolution of EV technology according to historical phases of EV development (Callon, 2012; Dijk et al., 2013; Rezvani et al., 2015; Situ, 2009). Reviewing the historical development of EVs, this technology has also failed to achieve public acceptance for a variety of reasons.

The 'early days' stage describes when EVs were among the first automobiles to be designed and were considered for production years earlier than combustion engines (EVs led by a ratio of 3:1 compared to gasoline vehicles in the late 1920s to 1930s). In the 1930s, gasoline vehicles overtook EVs' popularity and have been the leading technology in performance and costs ever since. The main drivers of the worldwide demand for combustion cars are considered to be; cheap petrol/ diesel costs, the ability to easily transport petrol/ diesel, and the development of an infrastructural system. During the ‘midterm’ period (1930s-1980s), EVs gained a renewed momentum due to the political sensitivity of energy independence in the 1960s and the energy crisis of the early 1970s, however this popularity quickly fell away. This decline tends to be explained by; EVs’ limited performance compared with the development of conventional cars’, their purchase price, the lack of supporting infrastructure for EV technology, and limited governmental support (Situ, 2009).

4.3.2 EVS’ SMART GRID POTENTIAL – NEW MOMENTUM?

The general assumption in the literature is that the ‘present’ reinvention of EVs stems from the technology’s plug-in potential and the current trend for socially responsible decarbonisation of energy infrastructure. This smart grid perspective on the adoption of EVs has emerged in the literature since 2008, resulting in a considerable number of studies investigating smart electricity grid development and the effects of EV-charging on the distribution network and energy system (i.e. Galus et al., 2010; Green II et al., 2011; Rotering & Ilic, 2011; Rutherford & Yousefzadeh, 2011; Stephan & Sullivan, 2008)

The widely accepted notion is that electric mobility has huge potential to balance fluctuations in electricity demand and supply, which are seen as major challenges for the successful development of a future energy system that incorporates renewable energy sources. Renewable energy sources, as wind and solar, are only generated when the wind is blowing or the sun is shining, which require strategies to manage energy demand and supply fluctuations of varying timescales. The expectation is that EVs can support these challenges due to the technology’s vehicle-to-grid ability to integrate renewables into existing electricity systems (Bradley & Frank, 2009; Dijk et al., 2013; Richardson, 2013). Further, the electric engines’ ‘peak-shaving’ potential is leading to explorations of EV’s potential for demand-side management, whilst households’ flexibility to time shift their energy-consuming activities, has also begun to seriously influence the political agenda.

This newly-found momentum for EVs framed in the era of climate change, has been accompanied by regulatory frameworks and market instruments that are designed to curb emissions, by intensifying strategies for the electrification of mobility. This ‘shift’ in governmental rhetoric resulting from the vehicle-to-grid aspect (Rezvani et al., 2015), has been led by; carbon-reduction policies, new value propositions by business, and attempts to develop a positive image of electric driving. Together these strategies are developing a new pathway for the electrification of cars (Dijk et al., 2013). Lixin Situ makes this optimistic forecasting clear in the following quote,

> “However, more recently, an electrification trend in the automotive industry has evolved and will revolutionize the industry. With the correct policy and government help and advancement of electric vehicle technology, the prospect of Electric Vehicle will be bright and the focus point of future development” (Situ, 2009:1), and he further states, “Electric vehicle will be the final goal” (Situ, 2009:3).

In regard to the current global hype concerning ‘going electric’, it seems appropriate to conclude, as Bakker and Farla (2015) have, that the EV technology has moved beyond the pilot and demonstration phase.

Some of the central trade-offs associated with this perspective relate to: balancing consumer need/choice for vehicle charging with EVs’ demand response (Lemoine et al., 2008); the planning, organisation and economics of (fast and reasonable) charging infrastructure for EVs (Gallagher et al., 2011; Richardson et al., 2012; Dong et al., 2014); development of optimal charging control in respect to environmental issues and the electricity supply system (Galus et al., 2010; Druitt and Früh, 2012; Dallinger and Wietschel, 2012); and the financial benefits received by EV owners from flexible vehicle charging (Druitt & Früh, 2012).

Other crucial factors contributing to the current momentum for EVs include: peak oil expectations and the unpredictability of future oil prices which have highlighted the development of vehicles that do not depend on oil; progress made in battery technology, which has lowered the cost of EVs; new EV promotions, such as battery leasing and mobility packages intended to arouse the curiosity of potential purchasers and widen consumer choice; realisation by fleet operators of an increasingly positive image of EVs that is growing amongst consumers and policy-makers; communication strategies highlighting EVs’ reduced driving costs compared to conventional cars; economic recovery programmes in the US and Europe that favour clean technologies, including EVs; and car manufacturers growing adoption of a diverse portfolio of vehicles, including hybrid and pure EVs (Dijk et al., 2013).

Despite the above positive discourses and assumed advantages, EV adoption rate is considered globally insignificant, apart from few national exeptions for example, in Norway and the Netherlands. Mainstream arguments explain this slow adoption as due to: expensive EV purchase prices; a lack of reliability due to EVs’ limited driving range; a paucity of recharging stations; the time taken to recharge EVs; the current dominance of cultural attachment to owning rather than leasing vehicles; doubts that (hydrogen) fuel-cell technology will be ready for commercial use in the coming years (Dijk et al., 2013); uncertainties in the scale and timing of market diffusion (Tran et al., 2012); the unclear lifespan and replacement costs of electric batteries, the effect that used batteries have on the resale value of EVs; development of other competitive clean technologies (for example, hydrogen fuel-cell technology); battery capabilities and load management; the lack of definitive governance and standardisation (including standards relating to the recharging of EVs) (Brown et., 2010; Dijk et al., 2013; Sovacool & Hirsh, 2009).

Technological challenges are in general connected to manufacturers' continued large investments and development of more and more reliable attributes as well as reduced purchase price of conventional cars (Bakker et al., 2014; Tran et al., 2012).[2] In contrast, behavioural challenges relate to the perceived disruption associated with having to 'plug- in' to the grid, (re)charge EVs, and potentially time shift electricity-demanding behaviours (such as recharging), in order to release the 'green' potential of this technology.

4.3.3 LOW EV ADOPTION RATES – WILL THE NEW MOMENTUM LAST?

Whilst there is growing acknowledgement that EVs have today crossed a critical threshold (Bakker & Farla, 2015; Dijk et al., 2013; McMeekin & Southerton, 2012) and that widespread adoption of this technology will play an important role in integrating renewable energy into the existing electricity system (Richardson, 2013), there is still doubt about whether this current momentum can and will last (Bakker & Farla, 2015). The EV market is however still in the nascent stage. In 2011, the EV market share comprised only 0.06% of the 51.1 million light duty vehicles sold in the EU, US and key Asian markets (Rezvani et al., 2015). Global and European sales are still small, representing below 1% of new car registrations (McKinsey&Company, 2014; Sierzchula et al., 2012). As demonstrated in the following, mainstream governance approaches consider EV purchase price and driving range as the key challenges for large-scale adoption. Correspondingly several demonstration projects underline purchase price, time of battery charge, and infrastructural conditions as main concerns amongst consumers (i.a. Daziano & Chiew, 2012; Franke & Krems, 2013; Friis & Gram-Hanssen, 2013; Peters & Dütschke, 2014). As such, technical features, such as battery advancement intended

[2] Studies indicate that advances in conventional car technology could achieve 13-30% efficiency gains over the next 8-10 years (Fontaras & Samaras, 2010)

to extend driving range and lower purchase prices, are conceived as crucial features to ensure EVs develop the same positive attributes as conventional cars, and to ensure EVs become a real substitute (Simic et al., 2014).

In contrast, several demonstration projects show that current EVs do meet drivers' daily needs, which could indicate that perceived consumers' concerns are to some extent biased. For example, some studies based on GPS data metering of the driving patterns of potential EV adopters given the opportunity to test an EV confirmed that EVs largely covered these drivers' daily needs (Franke & Krems, 2013; Khan & Kockelman, 2012; Ramsbrock et al., 2013; Simic et al., 2014). In addition, results from Clever's demonstrations project concluded that the tested EVs were able to cover 98.9% of the participants' trips during the three months of test-driving. The majority of these empirical studies indicate that consumers become more positive about EVs once practical encounters with electric driving are made and personal experiences are developed distances (Clever's final report, 2014; Martin et al., 2009; Peters & Dütschke, 2014; Ryghaug and Toftaker, 2014). Additionally, these studies show that the EVs' average driving distances fail to differ significantly from test-drivers' conventional driving distances.

In spite of this driving range potential, evaluations from such demonstration projects emphasise test-drivers' considerable range-anxiety and their continuous preferences of vehicles boasting a higher available range following the test-period. This indicates that users' range preferences are substantially higher than their average commuter range needs. Sovacool and Hirsh (2009) argue that anxiety about driving range and the norms linked to required daily use increases EV drivers' level of planning and coordination (Sovacool & Hirsh, 2009). Moreover, a dominating assumption is that the high purchase price of EVs is incompatible compared to conventional cars. Conversely, recent studies demonstrate that EVs are actually cheaper than conventional cars over a five-year period when considered in terms of average life cycle costs/ total purchase price (Danish Electric Vehicle Alliance, 2013). In this regard, several studies indicate that psychological barriers, such as range and resale anxieties, are holding back EV adoption (Clever's final report, 2014; Franke & Krems, 2013)

According to these studies, EV adoption is associated with significant mental barriers, which are tightly connected to conventional mobility perceptions and norms based on driver independence and flexible decision-making. In other words, conventional driving has substantially enhanced personal mobility, freedom and associated prosperity. The potential to eliminate the perceived negative side-effects synonymous with EV driving appears to require compromises to the notion of mobility, and further challenges drivers' understandings of freedom and flexibility. In this regard, EV adoption seems to go beyond the dominant views that enhanced EV adoption will occur simply by 'fixing' the technology.

4.4 GOVERNING EV ADOPTION

As noted above, increasing expectations around electrification of cars is directly linked to the key driving issues of this century: climate change, peak oil prices and energy independence (Al-Alawi & Bradley, 2013; Dijk et al., 2013; Martin et al., 2009; Rezvani et al., 2015; Richardson, 2013; Tran et al., 2012). For this reason, a variety of governance incentives and more stringent regulations, in the EU, US, and Japan, have been developed to attempt to drive the automotive industry towards further commercialisation of low- and zero-emission vehicles.

4.4.1 GOVERNANCE OF EVS FROM AN EU LEVEL

Transport is responsible for around a quarter of EU greenhouse gas emissions, making this sector the second biggest greenhouse gas emitter after energy production. Road transport alone contributes approximately one-fifth of the EU's total carbon dioxide[3] emissions, but air pollution and noise impacts also create severe public health problems in urban areas (Nykvist & Nilsson, 2015).

Whilst greenhouse gas emissions in other sectors decreased 15% between 1990 and 2007, emissions from transport increased 36% during the same period, despite improved vehicle efficiency. With the highest projected emission growth rates[4], transport emissions were 20.5% higher in 2012 than in 1990[5] and need to fall by 67% by 2050, in order to meet the 2011 Transport White Paper target emissions reduction of 60% compared to 1990. This White Paper provides a roadmap of 40 concrete initiatives that are required in order to build a competitive and sustainable transport system over the next decade. By 2050 the key goals include: no longer having conventionally-fuelled cars in cities, 40% use of sustainable low-carbon fuels in aviation; at least a 40% cut in shipping emissions; and a 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.[6] To conclude, fuel efficiency is considered to be the most

[3] http://ec.europa.eu/clima/policies/transport/index_en.htm
[4] UNEP, 2012. The Emissions Gap Report 2012. United Nations Environment Programme (UNEP), Nairobi.
[5] http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm
[6] White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system /* COM/2011/0144 final */.

significant instrument for reducing carbon emissions. To this end, development of EVs and PHEVs are expected to help to solve the future emission reduction challenges, as regulated by increasingly stringent EU standards and innovative vehicle taxation systems.

As a part of the EU's energy and climate goals for 2030, the renewable energy directive sets a binding target of 20% final energy consumption from renewable sources by 2020[7]. To meet this target, every EU country is required to derive 10% of their transport fuels from renewable sources by 2020. Therefore, all EU countries have adopted national renewable energy action plans to demonstrate their intended actions for meeting their targets[8]. Countries' renewable energy ambitions range significantly due to: different national emission reduction targets; contrasting plans for electricity, heating and cooling, and transport; and the mix of existing and anticipated renewable technologies and cooperation strategies.[9] Overall this directive sets out a clear framework for renewable energy transition, intended to reduce carbon emissions and promote cleaner transportation across Europe.

Another relevant initiative is the EU's Fuel Quality Directive[10], which is intended to encourage the deployment of innovative vehicle technologies in order to reduce greenhouse gas and air pollution emissions. The directive applies to all petrol, diesel, gasoil and biofuels, used in road transport, and requires car manufacturers to reduce average vehicle emissions by 6% by 2020. Overall, the common fuel quality rule is regarded as an important driver for ensuring that vehicular air pollution emissions are optimally reduced, in order to establish a single fuel market and to ensure that vehicles operate legally across the EU.[11] As such, the directive proposes a methodology for calculating the greenhouse gas intensity of fossil fuels used in transport systems.

Furthermore, EU legislation sets increasingly stringent binding emission reduction targets for new cars (and vans) that were/are to be introduced in 2015[12] and 2021 respectively. These targets are seen as the cornerstone of the EU's strategy to improve the fuel-economy of cars sold on the European market. Recent carbon

[7] The member states have already on a new renewable energy target of at least 27% of final energy consumption in the EU as a whole by 2030.
[8] Every 2nd years, the EU countries publish national renewable progress reports.
[9] http://ec.europa.eu/energy/node/69
[10] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0030
[11] http://ec.europa.eu/clima/policies/transport/fuel/index_en.htm
[12] Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014.

emission reduction targets that require a 95g CO_2/km fleet average in EU countries from 2021 may further reinforce the view that EVs are part of the solution for a sustainable transport system. The aim is to give the car manufacturers the political certainty required to carry out long-term investments and develop innovative technologies. Moreover, this legislation requires Member States to ensure that relevant information is provided to consumers, for example, labels showing the fuel efficiency and carbon emissions of new vehicles (i.e. the Car Labelling Directive 1999)[13]. 'Super credits' forms a crucial part of this regulation, by providing car manufacturers with additional incentives to produce vehicles with extremely low emissions (such as EVs and PHEVs). The aim is to increase incentives for enrolling new technology and innovation within the car manufacturing industry, which is often costly. Furthermore, 'Euro norms' influence national transport policies, by defining acceptable exhaust emissions limits for different vehicle types. Notably, all major car manufacturers today offer pure EVs and PHEVs as part of their fleets, indicating that the industry anticipated that these vehicular alternatives will help to provide answers to societal concerns about the future unsustainability of conventional passenger cars (Dijk et al., 2013; Sierzchula et al., 2012).

Overall the European Commission's Joint Research Centre (JRC) underlines the importance of regulatory and financial support to encourage the development of EVs. Findings in a JRC report outline projects in receipt of EU or national public funding during the period 2007-2015, and show that the majority of EV R&D projects focus on; control systems, energy storage, and the design and development of the car body. Furthermore, main challenges in the majority of EV demonstration projects relate to infrastructural constraints and range anxiety. They therefore mostly focus on; testing vehicle-to-grid aspects, developing innovative solutions for car technologies, demonstrating different business schemes, and improving charging infrastructures. The report outlines the concentration of EV demonstration projects in large capital cities and divides projects into either field-testing and infrastructural development in larger urban areas, or attempts to establish 'model regions' for the introduction of different types of EV models and business schemes (European Commission JRS, 2013).

4.4.2 NATIONAL GOVERNANCE STRATEGIES

Whilst EU standardisation and regulation initiatives have increasingly significant impact on EV adoption and market expansion at a national-level, EV adoption policies are variously implemented across different European countries. Different

[13] Directive 1999/94/EC of the European Parliament and of the Council of 13 Dec. 1999.

national governance strategies are manifold, but typically policies and regulation instruments promoting EV adoption focus on; the anticipated economic impacts of state taxes, subsidies, and rising gasoline prices. For example, some scholars examine the impact of gasoline prices and government-led incentivisation policies, and suggest that gasoline prices are more effective than incentivisation (for which they advocate payments upfront) when it comes to EV adoption (Diamond, 2009). To show the diversity of policy instruments, initiatives and programmes, a sample of country-specific strategies are presented below.

The urban mobility potential of EVs has encouraged local and regional policies and regulations intended to develop infrastructural systems, but also provide economic incentives as influenced by the national governance agenda (Danish Energy Agency, 2014). Whereas EU governance incentives influence on member states' policy agendas, national policies vary due to regulations for; car taxes (fees for vehicle registration and on fuel), stakeholder interests, existing conditions of local energy systems, and planned smart grid strategies (Christensen et al., 2013a). As noted, available renewable energy sources are crucial to achieving international and national targets for decarbonisation. Given this, the potential of EVs to reduce carbon emissions varies according to the mix of energy sources available to different countries. Carbon emission reductions are high in Norway due to the high amount of hydropower, whilst, reductions in Denmark are expected to increase as a greater proportion of renewable energy comes from wind power. Conversely, the energy mix in Germany to a large extent still consists of fossil fuels, which is why the uptake and contribution of EVs to the grid is anticipated to be limited until 2030 in this country.

Compared with other countries, EV adoption is high in Norway. Whilst 4,000 Tesla model S cars were sold in Norway in 2014, the Danish sale rate peaked at around 460 sold cars.[14] In 2012, Norwegian politicians decided to increase economic incentives for EV-investment (Norwegian Ministry, 2012; Ryghaug & Toftaker, 2014:147). Today over 50,000 EVs are driving around this oil-rich nation, which makes Norway the country with the most EVs worldwide. In 2016, Norway achieved a new registration record, with 4,634 newly registered PEVs, taking the PEV market share to 30%[15]. This rapid expansion of EVs has been encouraged by strong financial and regulatory incentives. Some of the most significant incentives to increase EV adoption in Norway include; vehicle purchase tax exemption, free tollroads, ferries, free-parking, access to bus lanes and the availability of charging

[14] http://www.business.dk/transport/olielandet-norge-er-ved-at-drukne-i-elbiler
[15] http://www.elbil.no/nyheter/statistikk/3760-elbilsalget-oker-i-europa

stations (Ryghaug and Toftaker, 2014).[16] Furthermore, the relative price difference between the costly Tesla, which is seen as a highly luxurious EV, and conventional 'micro-cars' is much smaller. Strict import regimes and purchase taxes have resulted in that conventional cars being up to twice as expensive to buy in Norway than in other European countries (Ryghaug & Toftaker, 2014:147). Additionally electricity prices, compared with fossil fuel prices are considerably lower in Norway than in other countries (Danish Energy Agency, 2014; Grønn Bil Prosjektrapport, 2013). The tax system is considered as an active instrument for meeting national carbon emission reduction targets[17]. Nevertheless, the rise of EVs in Norway does not necessary limit the sale of combustion cars, should EVs become a supplementary second and third car. Consequently, whilst EVs are still being expensive for their size and comfort class, they have become an alternative vehicle for many Norweigan households (Ryghaug and Toftaker, 2014).

In contrast to the Norwegian EV adoption scene, EVs have hardly been supported or adopted in Sweden. Some scholars explain this trend by Sweden's former focus on transport powered by biofuels, which led to the development of a widespread charging-infrastructure for ethanol cars (Danish Energy Agency, 2014). In a case study, the very low uptake of EVs in Sweden is explained by general lack of strong policy signals favouring EVs and their limited diffusion is attributed to the former Swedish policy support of ethanol-fuelled cars. This policy route is today perceived as having been a major mistake[18] (Nykvist & Nilsson, 2015).

Specific institutional settings are highlighted as significant for the development of electric mobility in another study of EV adoption in Quebec (Canada). Here it is stressed that growth of the hydropower sector in Quebec over the past 40 years, together with organisational and institutional resources, legitimised innovation in batteries, and contributed to a nascent electrified mobility sector. The study illuminates how EVs have failed to become a successful innovation here however due to a lack of relevant national resources, such as automotive expertise (Haley, 2015). In addition, a study by Mazur et al., (2015) underlines how current policies designed to stimulate EV adoption in Germany and UK, go hand-in-hand with industrial competiveness, and depend on the national car sectors' specific

[16] Norway has the most EV economic incentives of any European country: Registration Tax Benefits, Ownership Tax benefits, Company Tax Benefits, VAT Benefits, Other Financial Benefits, Local Incentives, and Infrastructure Incentives.

[17] In Norway, hydropower generated from gushing rivers, rather than wind power, powers EVs.

[18] However, the Swedish Government has earmarked around 3.5 billion to invest in EVs, PHEVs and related infrastructure from 2014-2025.

circumstances (Mazur et al., 2015). Hence, the authors suggest that the sizeable car-manufacturing industry in Germany might hinder Germany from meeting national and international road transport emission reduction targets.

The Danish Government has a target to be independent of fossil fuels by 2050. As such, EVs are expected to become 'cleaner and greener' over the next decades. Like for other EU countries, Danish policy incentives comprise different economic instruments as; an exemption of EVs registration fees and vehicle excise duty until end 2015; compensations for EV charging at a commercial scale; and energy utilities ability to 'buy' energy-reduction 'credits' in relation to undertaking EV-charging initiatives and for providing financial support to EV-partnerships and demonstration projects[19]. Moreover, several provider agreements offer a discount on electricity prices, and since the end of 2012, Denmark has developed a nation-wide electricity-charging infrastructure, as developed by Clever. With respect to these ambitious policy targets and the now established nation-wide infrastructure, the uptake of EVs can be considered as notably slow. In December 2014, total sale of EVs in Denmark was approximately 3000[20], which is 13 times lower than for Norway[21].

Given the preceding discussion about ambitious international and national discourses and initiatives, electric mobility is becoming a reality, however its (s)low uptake largely remains a vision. Governmental targets and regulations tend to favour strategies focusing on economic instruments that are intended to increase the incentives for consumers and industries to invest in EVs. Technological fixes and economic incentives dominate European and national governmental agendas, and these approaches are considered as sovereign solutions for intervention. The common assumption here is that lower purchase prices and improved technologies will make EVs into an economic and rational choice for consumers. The dominant expectation is that the sale of EVs will accelerate when their purchase price falls and EV infrastructure functions effectively and reliably. Hence, economic incentives and technological solutions are seen as the main drivers for reducing carbon emissions within the Danish transport sector.

Based on a follow-up meeting with Clever's head of communication (8th March 2016), the following table illuminates some of the most 'critical events' in EV adoption in Denmark, as depicted from the operator's perspective.

---

[19] http://www.ens.dk/klima- CO2/transport/elbiler
[20] http://www.danskelbilalliance.dk/Statistik/Salgstal_maaned.aspx
[21] https://www.dr.dk/nyheder/penge/norge-har-nu-13-gange-saa-mange-elbiler-som-danmark

Table 5: Some of the 'critical events' influencing on EV adoption in Denmark

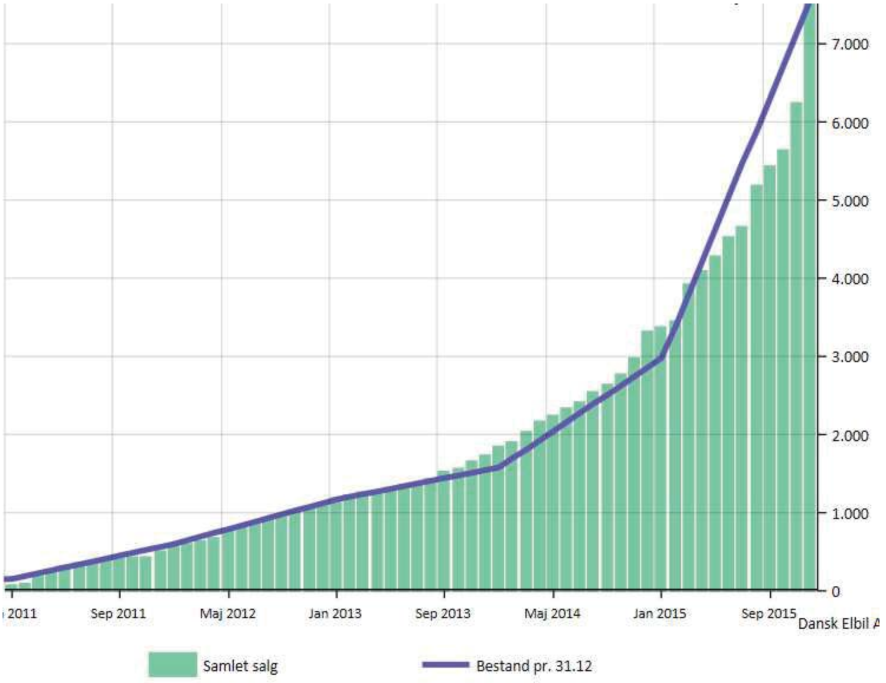
Year	Events influencing EV adoption
1984	EVs exempted from registration fees
2009 (feb)	BetterPlace established in Denmark
2009 (nov)	TEV (at that time 'ChooseEV') established
2009 (dec)	COP15: Climate Summit in Copenhagen
2009	EVs temporally exempted from registration fees until 2012
2010 (dec)	Test-an-EV (TEV) initiative commences (ends June 2014).
2011 (jan)	200 of the first commercially produced EVs 'the twins' come to DK.
2012	Nissan LEAF launched in DK – advance in technology compared with 'the twins'.
2012	Danish Government extends EVs' exemption from registrationfees until 2015
2012 (june)	Clever opens a nation-wide charging infrastructure of 50 kW charging units.
2013 may)	BetterPlace goes bankrupt (technology related to batteryshift stations ends). Prior to this, Renault declares their next EV will not need to battery-shift.
2013 (sep)	E.ON buys BetterPlaces' load boxes
2014 (may)	Tesla opens first super-charging stations in Denmark
2014	BMW i3, Wolkswagen eUP and eGOLF launched in Denmark
2014	EU directive on alternative fuels becomes effective. European plug-standards are enacted (Combo + Type 2)
2014-2015	Clever changes its charging network from CHAdeMO to three plug-ins (CCS, CHARdeMO, Type 2)
2015 april)	Clever opens in Sweden
2015	Danish Government implements gradual phase-in of registration fees for EVs over a five-year period, so EVs are to be fully 'taxed' by 2020 (20% more every year).
2015	Drive Now project starts in Copenhagen (400 BMW i3)
2015 (dec)	Clever opens four 50 kW charging units in North of Germany

The 'green' colour illustrates initiatives/ regulation implemenented at a State level. The 'orange' colour refers to Clever's initiatives. The 'red' colour points to significant innovation in EV technology. And the 'blue' colour describes other EV initiatives.

Although the EV 'revolution' has been far slower than expected in Denmark, Figure 11 indicates the importance of political regulation (e.g. exemption of registration fees and taxes) for increasing EV uptake. In particular, the following figure illustrates how the sale of EVs increased in 2015 due to the Danish

Government announcing that they were to reintroduce registration fees for EVs in June 2015.

Figure 11: The EV uptake in Denmark over the recent years.



The figure illustrates sale and population of EVs in Denmark during the recent years. The green colour represents the total sale of EVs, and the blue curve indicates the total fleet of EVs per 3,112 each year. Source: http://www.danskelbilalliance.dk/.

4.5 THE DOMINANT RATIONAL REGIME

Like mainstream policy approaches, the majority of published research articles on EVs highlight techno-rational aspects of adoption (and non-adoption) behaviour (Rezvani et al., 2015). Due to the current low market share of EVs, these studies largely focus on predicting and modelling consumers' intentions for adoption, instead of reflecting on the actual EV adoption rates (Al-Alawi & Bradley, 2013; Rezvani et al., 2015).

4.5.1 RATIONAL CHOICE THEORY & THEORY OF PLANNED BEHAVIOUR

Rational approaches to understanding consumer adoption of EVs utilise theoretical concepts based respectively on Rational Choice Theory (RCT) and the Theory of Planned Behaviour (TPB). Despite some diversity, the large majority of such studies suggest that EV adoption (and car ownership more broadly) depend on consumers' individual beliefs, attitudes and behavioural intentions. RCT asserts personal benefits and utility as the basis of human behaviour, and has in particular focused on instrumental attributes such as; purchase price, running costs, reliability, performance, driving range, and (re)charging time (Rezvani et al., 2015). In general these studies attempt to predict and 'model' consumer purchase intentions for EVs by 'measuring' consumers' rational behaviours, preferences, decisions and attitudes (Daziano & Chiew, 2012; Eppstein et al., 2011; Jensen et al., 2013; Krupa et al., 2014; Schulte et al., 2004; Shafiei et al., 2012; Zhang et al., 2011).

These calculative models make 'hypothetical' estimations of EV market penetration rates and compare the attributes of a specific set of vehicles compared to alternatives on the market, from which they forecast consumers' preferences (Al-Alawi & Bradley, 2013). Consumers are expected to act and make EV purchasing decisions according to widely held norms and values that relate to existing technology. According to this perspective, consumer preferences, perceptions and decision-making are highly dependent on the value added to 'new' EV technologies. This corresponds to the view that transport policies and EV diffusion strategies should focus on making EVs superior in their operational performance compared to conventional cars, increasing the financial benefits associated with driving an EV. As Eppstein et al. (2011) state,

> "Our simulations indicate that PHEV market penetration could be enhanced significantly by providing consumers with ready estimates of expected lifetime fuel costs associated with different vehicles (e.g., on vehicle stickers), and that increases in gasoline prices could nonlinearly magnify the impact on fleet efficiency"[22] (Eppstein et al., 2011:3789).

In addition, continual comparisons with conventional vehicles emphasise the need to develop EVs with similar attributes to existing technologies, and to ensure that the design process enables driving and battery recharging processes that require as little behavioural change as possible (Caperello & Kurani, 2012; Sovacool & Hirsh, 2009).

---

[22] Notably, the oil prices were still high and rising in 2011.

Like RCT, Theory of Planned Behaviour (TPB) assumes that human beings make decisions on rational evaluations of stimuli and the possible consequences of enacted decisions. Human behaviour is rationally selected and undertaken by practitioners, who intentionally take decisions based on particular goals (Ozaki & Sevastyanova, 2011). Planned behaviour models focus on consumer beliefs and attitudes, which are directly predicted by these individuals' intentions for action (Ajzen, 1991; Ozaki & Sevastyanova, 2011). EV adoption studies based on this psychological theory consider consumer intentions and behaviours as shaped by attitudes, subjective norms, and perceived behavioural control. Hence, the more a consumer perceives behaviour to be a social norm, the more likely the subject intends to perform or change behaviour to align with shared norms. Subjective norms are determined by people's perceived expectations of a specific reference group, such as family or society (Ozaki & Sevastyanova, 2011). Controlling beliefs refers to the constraints experienced in reality and an individual's ability to perform certain behaviour.

Drawing on TPB, some scholars have highlighted emotions and attitudes towards EVs as the strongest determinants of usage intention, followed by subjective social norms (Moons & De Pelsmacker, 2012). Hence, a general assumption for studies adopting this particular theoretical framework is that consumer knowledge and experience are crucial for consumer adoption (Augenstein, 2015; Franke & Krems, 2013; Peters & Dütschke, 2014; Rezvani et al., 2015; Shiau et al., 2009). In addition, Ryghaug and Toftaker 's (2014) study of EV-driving in Norway demonstrates that the 'meaning' of driving electric increases with 'hands-on' practice experience, and they consequently suggest that more practical EV driving performances would be beneficial to encourage consumers' acceptance of EVs as a viable transportation alternative (Ryghaug & Toftaker, 2014). Further, several studies emphasise the importance of providing information about EV technologies, suggest that potential EV 'drivers' could gain by others' being transparent about their concerns, and emphasise that ideally consumers should practically experience the technology on their own (Budde et al., 2015; Ozaki & Sevastyanova, 2011).

Although, EV adoption studies are predominantly underpinned by either technical, behavioural or economic understandings, a growing number of interdisciplinary comprehensions of EV adoption are coming to the fore in this debate. These studies highlight the symbolic, normative and emotional dimensions of consumer behaviour as crucial for mass EV-adoption, which are reviewed in the following.

4.5.2 SYMBOLIC, NORMATIVE AND EMOTIONAL APPROACHES

In contrast to purely rational behavioural modelling approaches, increasing research recognises normative and emotional factors, as well as symbolic meanings, as having significant influence on EV adoption. These, primarily empirical studies, show how comparative approaches specifying differences between EVs and conventional cars are insufficient, and emphasise how ‘softer’ values associated with EV-adoption need to be examined as well (Kawgan-Kagan & Daubitz, 2014). Such sociological and psychological based theories describe symbols and/ or symbolic meanings of EVs and their relationship with self-identity and self-image. Consequently, these studies stress how symbols linked to EV-driving play a significant role in consumer adoption.

EVs are products that have symbolic meanings, which help consumers to define and express who they are (Graham-Rowe et al., 2012; Ingeborgrud, 2014; Peters & Dütschke, 2014; Schuitema et al., 2013). In particular, environmental concerns and ‘greener-driving’ performance are expressed as important elements in the construction of EV-drivers’ self-identity. Furthermore, Schuitema et al., (2013) found that consumers who have a pro-environmental self-image are more likely to have positive perceptions of EV attributes. In addition a PhD-study by Ingeborgrud (2014) showed how EV drivers found it more comfortable to drive EVs when they identified with having ‘green’ values. Hence, comfort can be considered as associated with the symbolic aspects of more environmentally friendly driving (Ingeborgrud, 2014).

While rational-based theories explain pro-environmental behaviour as a product of pure self-interest, normative theories, such as Value-Belief Norm (VBN) theory (Stern, 2000), explain pro-environmental behaviour (for example, EV adoption) as motivated by internal beliefs and values (Rezvani et al., 2015). In this respect, personal norms, such as strong moral obligations, are direct determinants of pro-social behaviour (Ozaki & Sevastyanova, 2011). Studies demonstrating how EV adoption crucially depends on changing social norms, stipulate the importance of social networks and neighbour effects for influencing consumer behaviours (Axsen et al., 2009; Daziano & Chiew, 2012; Mau et al., 2008). These studies tend to emphasise how environmental beliefs, social effects, and consumer awareness of environmental issues, affect consumers’ intentions to make an EV purchase (Egbue & Long, 2012; Ingeborgrud, 2014; Lane & Potter, 2007; Peters & Dütschke, 2014). In contrast, some studies show consumers’ doubt about EVs’ positive environmental impacts, leading to reduced adoption rates (Caperello & Kurani, 2012).

Theories on diffusion of innovation and consumer innovativeness provide another theoretical approach used to identify and profile early EV adopters (Rezvani et al., 2015). This approach links an individual's intention to adopt an EV to consumer innovativeness and perceptions of (eco-) innovations (Schuitema et al., 2013). Going beyond rational choice and cognitive assessment, the adoption and diffusion of innovation is recognised as a social process that is influenced by emotional and socio-cultural issues (Ozaki & Sevastyanova, 2011). Moreover, scholars call for further insights in consumer emotions, to better understand, inform, and encourage consumer adoption (Rezvani et al., 2015). In this regard, Schuitema et al., 2013 emphasise how emotions such as; joy, pleasure, pride and embarrassment, play a significant role in levels of consumer innovativeness. Such emotions are considered as important for overcoming some of the policy barriers to EV diffusion, and in particular, for informing communication and education strategies for EV adoption.

4.5.3 GAPS IN CURRENT EV ADOPTION RESEARCH

The above account of how human-centred psychological and economically-oriented theories are frequently translated into policy, adopts the approach that the uptake and diffusion of new technology is a matter of an individual's rational choices and decision-making. Rezvani et al.'s (2015) literature review reveals some significant limitations in studies and interventions that rely on such frameworks to understand EV adoption. The scholars first problematise the fact that many studies are based on survey responses from participants with no direct experience of EV driving, which limits the validity of inferences about adoption that might be drawn from their responses. Second, they stress how studies of participants' actual experiences tend to be based on samples of 'early technology adopters', which are biased by these individuals' increased motivations, and therefore perceptions of investigated EV drivers attitudes and experiences might not represent the majority of consumers (Rezvani et al., 2015). Related to this, third, they problematise the fact that the majority of research is based either on forecasting or on samples of early adopters, and they suggest that this might explain the gap between consumers' predicted intentions to adopt, and realised levels of EV adoption.

Rezvani et al. (2015) call for increased research on the effects of policy processes and educational strategies on EV adoption and self-efficacy in driving EVs. They request a need to justify the use of different communication strategies for encouraging EV adoption, and suggest that industry and policy need to be aware of the potential risks and benefits of framing EVs as the cars of the future (Budde et al., 2015; Rezvani et al., 2015). Further, a recent study by Budde et al. (2015) demonstrates how the phenomenon of technological hypes – as a result of car manufacturers' optimistic expectations and promotion of EVs – eventually turns into consumer disappointment when technological progress fails to meet the proposed timeframe (Budde et al., 2015).

With regard to the insignificant number of EVs in use, it seems appropriate to problematise the tendency in the current academic literature to consider consumers as variously possessing the skills, competences and knowledge that will enable them to calculate and compare the financial benefits and costs of EVs. On this basis, given EVs' unpredictable and uncertain status, stakeholders have clear implications related to educating consumers about the financial benefits and costs of EVs *versus* conventional cars. In this regard, Rezvani et al., 2015 further underline that EV promotional policies and campaigns tend to overlook effectual environmental arguments. As such, they call for greater investigation of the role of symbolic meaning in EV adoption (in contexts other than US and UK), and for more research on the formation of green neighbourhoods. Acknowledging the dominance of 'techno-fix' and behaviouristic policies, these authors also suggest, a need for more research on consumers' perceived differences between EVs and conventional car technology. Further, they request greater investigation into the symbolic meanings associated with different types of EVs.

Last but not least, Rezvani et al. (2015) emphasise consumer habits and routines as an overlooked area in current EV research. This acknowledgement provides the basis for the position that this thesis takes; that there is a clear need to adopt an alternative theoretical framework.

4.6 SOCIO-TECHNOLOGICAL APPROACHES

Although techno-rational approaches dominate current understandings of EV adoption, a growing number of socio-technical approaches have gained greater traction over the last decades, contributing a broader approach for sustainable transitions within the transport sector. These approaches are both structuralistic and actor-based – where actors include; technology, industry, market behaviours, policy, infrastructures, and cultural meanings (Geels, 2005). As such, socio-technological transition approaches do not prioritise social or technical elements over one another, but see the two as inexorably linked (Geels, 2002, 2005; Geels & Schot, 2007; Rip & Kemp, 1998).

Instead of presenting linear cause-and-effect relationships (for example, between beliefs and environmental behaviours as ‘pushed’ by simple drivers), socio-technical transition perspectives emphasises mutually reinforcing developments, (sometimes unexpected) alignments, co-evolution, and circular causality (Dijk et al., 2013). As such, these approaches move beyond individuals’ perceptions and behaviours within their immediate contexts, and include a wide range of connected actors, agents and materials. In contrast to mainstream policy and research approaches, change is not driven by single factors such as price or technological attributes, but (typically) involves co-evolution between multiple developments and stakeholders at multiple scales: such as governments, consumers, providers of infrastructure, and car manufacturers. Socio-technical perspectives,

> “differs from functionalistic approaches that tend to focus on system functions being fulfilled (e.g., in industry sector assessments and comparisons of various technologies) or pure economic approaches (where cost, performance, prices, incentives are the main variables)” (Dijk et al., 2013:135).

4.6.1 TRANSITION TO ELECTRIFICATION FROM A MULTI-LEVEL PERSPECTIVE

Overall, the Multi-Level Perspective (MLP) delivers an analytical and heuristic framework to comprehend the complexity of socio-technical change across distinguishable scales (Geels, 2002). The approach describes transitions as an outcome of multi-dimensional interactions between radical niche-innovations, an incumbent regime, and an external landscape (Verbong & Geels, 2010), each representing different scales of dynamics, interlinked in a spatial dimension (Geels 2002). The multi-level model of innovation is distinguished by three levels; respectively the macro-, meso-, and micro-level. New socio-technical arrangements are developed in protected niches that form at the micro level. Developments at this micro-level are shaped by, and have consequences for, the formation of meso-level ‘regimes’. The meso/regime level in turn structures and is structured by macro-level landscapes. Stability is determined by the existing socio-technical regime, for example conventional car mobility is currently largely locked into internal combustion engines because the societal context has adapted to the use of cars in terms of anticipated speed and power, training and knowledge, and maintenance networks, regulations, cultural acceptance etc. (Geels, 2002). In contrast, interaction amongst the micro, meso and macro levels is important for (sustainable) transition in society, which requires that all three levels move into the same direction and reinforce each other (Verbong & Geels, 2010).

Studies based upon the MLP explain how EV adoption and diffusion require developments on different levels and include a complexity of factors and actors. Hence, Dijk et al. (2013) stress that the pathway for electrification of the transport system and progress in electric mobility require combined progress in battery technology as well as new value propositions, as established by policy and industry. In particular, regulations, standards and the establishment of a supportive infrastructure, are acknowledged to have a major influence on EV diffusion rates (Bakker & Trip, 2013; Brown et al., 2010; Cowan & Hultén, 1996; Dijk et al., 2013). A MLP-based study also suggests that stringent emissions reduction regulations and a rise in fossil fuel prices are two valuable regulation scenarios that might help to stimulate EV adoption that further would scale up car manufacturers experiments with alternative vehicles and increase commercialisation (van Bree, Verbong, & Kramer, 2010).

Based on the MLP theoretical framework, socio-technical transition to wide scale adoption of EVs – i.e. shifting from an automobility system based on fossil fuels and internal combustion engines, to one based on electricity, batteries, and electric engines – requires substantial organisational and institutional changes, which technological substitution alone cannot address. Bakker et al. (2014) are concerned about previous research on EV adoption that provides a simplistic examination of either the EV supply-side (strategies in the automotive industry) or demand-side (consumers’ acceptance of EVs). They warn that the dichotomy of a reluctance to change from the car manufacturers and the lack of enthusiasm among consumers easily could lead to an *impasse* in the EV innovation trajectory. Instead, they argue that a successful transition towards electric mobility depends upon cooperation among a broad set of stakeholders. They underline necessary involvement and coordination between relevant stakeholders (car manufacturers, national and local governments, the main stakeholders in the electricity industry, new businesses, and even some of the traditional oil companies) as crucial for continuing the development of the emerging EV transport system. Six potential conflicts of interest are identified: division of tasks within a public recharging infrastructure; the allocation of charging spots; the ways in which charging behaviour can be influenced; the role of fast-charging, technical standards for charging equipment; and supportive policies for full-electric and plug-in hybrid vehicles. Thus, the conclusion is that supportive policies will be necessary to provide a stable and reliable basis for further market expansion of EVs (Bakker et al., 2014).

Another study examines the role of standards, related training and certification for EVs (Brown et al., 2010). It is argued that EV diffusion requires; standardisation of training and certification for batteries and charging infrastructures, and electricity distribution that better accounts for renewably produced electricity and the differing aspects of vehicle-to-grid and smart grid technologies. Safety and performance amongst the training of professionals and support systems are also presumed as crucial to enhance consumer confidence and to expand a growing EV niche in the automobile sector. Hence, this transition perspective calls for further coordination and cooperation on a variety of scales, not least between national and trans-national levels (Brown et al., 2010). In particular, state-supported investment is considered as crucial for creating the necessary EV charging infrastructure (Bakker & Jacob Trip, 2013). Such a standard would provide a strong signal to prospective EV users and would make it easier for cities to set-up a recharging infrastructure. As mentioned previous, standardisation for charging plugs at the EU level is now a reality.

In addition to the above studies, Tran et al., (2012) emphasise that market diffusion of EVs requires integration between technology and behaviour. They conclude that EV diffusion will not be realised without change across different levels, which requires immediate and sustained policy support, industry investment and fundamental modifications in consumer behaviour. The authors emphasise that such an integrated approach for EV diffusion, highlights the importance of standards, policy and consumer incentives, technology impacts, constraints, advancements and inter-market competition. Like other MLP-studies into EVs, this research concludes that the EV market needs to be supported during the early phases by; policy (e.g. providing free EV-charging in public car-parking places), investors (e.g. expanding the charging infrastructure) and industry (offering vehicle leasing and other shared forms of ownership) (Tran et al., 2012). Overall, MLP is therefore useful to show how changes within one level, and/or interaction between levels, diffuse and stimulate change on other levels (Verbong and Geels 2010). These ideas have generated interest in the possibility that strategic intervention at the ‘niece’ level could start a cumulative sequence of events towards more sustainable socio-technical development of EV transportation.

4.6.2 ACTOR-NETWORK THEORY AND EV ADOPTION

Actor-Network Theory (ANT) is one of the most notable ‘arrangement’ concepts, and like MLP, this approach has been used to analyse the complexity of social life. Moreover this framework calls for greater focus on formulating a politics for socio-technical change, thereby dissociating itself from techno-centric and linear approaches of change. As well as other ‘arrangement’ or ‘assemblage’ theories[23], ANT attempts to illuminate the complexity of social life by acknowledging the co-evolution between human behaviour and technological systems in heterogeneous socio-technical networks. Suggesting that the world is assembled through interactions and network connections, the theory aims to understand these relations and interactions in order to make sense of socio-technical change and stability (Callon, 1986, 2012; Latour, 2005).

An obvious case to illustrate the actor-network approach is Michel Callon’s case study (1986) of EV development in France in the early 1970s. Callon’s case study shows how EV invention includes a variety of actors as electrons, catalysts, accumulators, users, researchers, manufacturers and a ministerial department – defined and enforced regulations affecting EV technology. All of these different actors, form heterogeneous entities that constitute a network that have the intention to develop EVs. These social and material elements, termed ‘actants’ interact to generate knowledge, through processes of social construction and material resistance (Callon, 2012).

Callon’s EV case demonstrates how a network is composed of a series of heterogeneous elements – both human and non-human – that have been linked to one another for a certain period of time. To increase the complexity of the analysis further, Callon stresses that behind each associated entity, hides another set of entities. Therefore he compared the actor-network with a ‘black box’;

> “It can be compared to a black box that contains a network of black boxes that depend on one another both for their proper functioning as

[23] Collectively these conceptualisations are known as ‘arrangement’ or ‘assemblage’ theories, including several different notions as: actor-networks (Callon, 1986), hybrid collectives (Latour, 2005), assemblages (Deleuze & Guattari, 1986), situational analysis (Clarke, 2005) etc.

> individuals and for the proper functioning of the whole. Therefore the operations that lead to changes in the composition and functioning of an actor-network are extremely complex“ (Callon, 2012:89).

Moreover, Callon argues that the whole structure of the network shifts and changes, when one element (i.e. fuel cells, users, system managers) is removed, because of the entities’ interrelations. Thus, the epistemological aim is to unmask these heterogeneous actor-network relations.

According to ANT, technological innovation and invention are a matter of a range of different socio-technical development on different scales in different times and spaces (Callon, 2012). Distinct from conventional approaches believing that initial problems associated with innovation must be solved through technical solutions, Callon emphasises that economic, social, political, technical and cultural considerations are inextricably bound up into an organic whole right from the start. Heterogeneity and complexity are present from the beginning, and are interwoven in a seamless web (Callon, 2012).

Successful EV innovation, which includes practice, entails that each component (actant) in the system, has to be designed to interact harmoniously with the characteristics of others. This means that actors (e.g. consumers, fuel cells and automobile manufacturers) must have their attributes defined and translated in order to play their assigned roles in the conceived scenario. To illustrate a sequence of events, their predictability and stability, Callon demonstrates how hydrogen feeds the fuel cells that power the motor that ensures the performances of VEL for which the users are willing to pay a certain price. Each element is part of a chain that guarantees the proper functioning of the object. As Callon states,

> “its success thus depends on the capacity to test certain resistances to their limits, whether these spring from social groups, cash flow, or electrodes to be improved” (Callon, 2012:90).

However, he also stresses how this ‘translation’ is difficult to change, fix and stabilise once it has been made. In this regard, for Callon’s case study, EV development failed, because the heterogeneous actors in the network reverted to their former roles.

Callon critiques sociologists for excluding material reality from their accounts of socio-technical change, which he suggests explains the coevolution of society. He also questions the neglect of heterogeneous associations among artefacts, which he contends are responsible for the success of a particular actor network. As he stresses,

> "The actor network describes the dynamics of society in terms totally different from those usually used by sociologists: if car users reject the VEL [EV] and maintain their preferences for different types of the traditionally motorcar, this is for a whole series of reasons, one of which is the problem of the catalysts that turn poisonous" (Callon, 2012:91).

Concluding, Callon declares that the concept of ANT enables sociologists to describe particular heterogeneous associations in a dynamic way, and to follow the passage of the network from one configuration to another. This in turn makes it possible to abandon pre-established social categories, and the rigid social/ natural divide, that are frequently characterist of the constricting framework of sociological analysis (Callon, 2012).

4.6.3 THE NEED FOR AN ALTERNATIVE APPROACH

The previous section outlined, compared and contrasted different theoretical understandings of the governance of EV adoption. I outlined how these approaches, whilst all concerned about the need to decarbonise current transportation through the electrification of temporary automobility, each contribute with very distinct contributions and conceptualisations on how future EV adoption will occur. The dominant techno-rational paradigm, which is supported by multiple political regulations and standards, considers technological investment and economic incentives to be crucial instruments of change. This indicates the mainstream tencency in both policy and research to take consumers' needs for granted, and focus on how the EV-technology is able to meet an assumed demand more efficiently. This confirms Shove and Walkers (2014) central concern about energy policies continuous avoidance of addressing the pivotal question about 'what energy and consumption is for?', which, they claim, marginalises different lines of enquiry and intervention (Shove & Walker, 2014).

A greater number of studies increasingly emphasise that the techno-rational focus on innovation is too simple, and that the distinction between technology and society is much more complex. Hence, the socio-technical approach emphasises transition as a more heterogeneous and complex process. These researchers see the world in terms of socio-technical configurations and co-constructions made of interactions and connections between heterogeneous elements. This breaks the constructed dichtonomy between the social and the technical worlds. MLP-studies generally privilege technological innovation and standardisation in their analysis of socio-technical transition. The MLP's recognition of multiple dynamics of practice configurations and path dependency of socio-technical systems and complexes has parallels with social practice-based approaches. Nevertheless, the MLP and social practice theory significantly differs in two key respects. First, social practice theory focuses on everyday 'doings' and 'stability' and/or 'change' as the outcomes of change and reproductions of practices (Shove et al., 2012:13). In contrast, the 'multi-level' model of social change and stability appears too ordered and too layered (ibid.), and is e.g. criticised for neglecting societal and cultural aspects of change (Geels, 2011). Instead of linear change, Shove and Walker highlight the horizontal circulation of elements of practice and argue for a flatter model characterised by multiple relations of reproduction that cut across different scales (Shove & Walker, 2010:474). As Shove et al. (2012) argue,

> "stabilization is not an inevitable result of an increasing density of interdependent arrangements, rather, practices are provisionally stabilized when constitutive elements are consistently and persistently integrated through repeatedly similar performances" (Shove et al., 2012:13).

Second, ANT gives non-human objects (e.g. fuel cells, catalysts, cash flows, batteries) the same ontological status as humans (e.g. users, car manufacturers and system managers). Shove et al., (2012) is concerned about how ANT views such 'stuff', and

> "do not go along with the idea (common in STS) that materials constitute the sticky anchor weights of social action or that they should be treated as immutable and relatively incorruptible transporters of power and influence" (Shove 2012:10).

Rather, theories of practice are concerned with non-human artefacts only if they are implicated in practice performances, because this approach is concerned about ordinary questions about what these hybrid entities are actually *doing.*

In the following chapter, I present the 'alternative' socio-technical approach adopted in this thesis – social practice theory – a framework which focuses on everyday 'doings' (which the previously introduced approaches tend to exclude). A practice-based approach to encouraging sustainable transitions, requires recognition that society is made-up of bundles of social practices, that are carried out and performed by practitioners in different time and space This theoretical and analytical lens of practice theory suggests that the decarbonisation of today's transportation sector requires intervention in practitioners' everyday social practices. Thus, this approach provides an analysis that views EV mobility and social change as highly interdependent, whereby socio-technical change for sustainability becomes a question of intervening in the dynamics of social practice. The intention is not to suggest that the entire dominant techno-rational paradigm is completely wrong or to criticise the preceding theoretical approaches. Instead, I seek to acknowledge how theories of practice, in the era of climate change and resource uncertainty, offer an understanding that is novel in focussing on transformations in/of practice.

5. THEORETICAL APPROACH

The four papers on which this thesis is based draw on different conceptualisations from social practice theory (SPT) as the underpinning conceptual and analytical framework. Due to the restrictive word count set for academic papers, in this chapter, I explain some of the core concepts of SPT and unpack what is meant by governing (un)sustainable resource-intensive practices, and shifting them in less energy-intensive directions.

As previously explained (see section 2.4), in each of the four papers making up this thesis, I have applied slightly different conceptualisations of SPT to pursue the aims and objectives, design the data collection process, conduct data analysis, and draw conclusions. Paper I recognises the current lack of focus on (and need for) the user perspective to feature within smart grid research, and emphasises how SPT helps to illuminate users' everyday 'doings'. Paper II analyses interactions between smart grid interventions and everyday household practices, focusing on the links occurring between practice elements, and how these relations can be reconfigured to form new practices (Gram-Hanssen, 2011; Shove et al., 2012). In paper III, the focus was on the temporal aspects of time shifting and how the 'temporality of practices' is crucial to understand when designing future smart grid interventions (Shove, 2003, 2009; Southerton, 2003, 2012; Walker, 2014). Paper IV used the 'system of practice' perspective to explain households' (non)adoption of EVs, and contends that sustainability transitions are ultimately dependent upon understanding and potentially changing existing systems of practices (Shove et al., 2015; Shove et al., 2012; Spurling & McMeekin, 2014; Watson, 2012). Whilst the different scope of SPT are explained in each paper, this chapter contributes details on the theory's fundamental ontology and key conceptualisations, and outlines some recent developments.

SPT is not a new, or unified, theory but rather an approach, or a theoretical 'turn', in sociological thought (Gram-Hanssen, 2011; Schatzki et al, 2001). The most recent coherent SPT approach builds on the philosopher Theodore Schatzki's rethinking and reworking of theoretical elements, based on work from prominent international social scientists such as Giddens (Giddens, 1984), Bourdieu (Bourdieu, 1990), Butler (Butler, 1990), Foucault (Foucault, 1978) and Latour (Latour, 1993). To get an overview of this approach, Halkier and Jensen (2008) divide the range of practice-aligned research approaches into two positions. On one side, scholars who attempt to systematise and position SPTs at a theoretical level by distinguishing them from other sociological theories (e.g. Reckwitz, 2002; Schatzki, 1996; Schatzki et al., 2001). On the other side, more operational and empirical approaches, occurring particularly in the area of consumption research (Shove & Pantzar, 2005; Shove et al., 2007; Warde, 2005), environmental and sustainability research (Burgess et al., 2003; Shove, 2003; Southerton et al., 2004; Spaargaren & Van Vliet, 2000) and in socio-technical research (Christensen & Røpke, 2005) (Halkier & Jensen, 2008). Further, I argue that recent developments within these theories have added a third dimension, which seeks to further ontologically redefine and reformulate SPT based on emerging empirical findings. Such recent contributions also attempt to address critical environmental sustainability and to accommodate socio-technical change(s) by drawing on systems-based transition theories. In my view, one of the core contributions to SPT is delievered by Matt Watson's 'systems of practice' approach (2012), and this is why I suggest that this new research category should be termed theories of 'systems of practice' (Shove et al., 2015; Spurling & McMeekin, 2014; Watson, 2012).

5.1 AN ALTERNATIVE APPROACH

Since Theodore Schatzki developed SPT's new impetus (Schatzki, 1996), some researchers have focused on how this approach can be used to understand transitions towards a more sustainable society by revealing processes of reproduction and change occurring in forms of consumption (McMeekin & Southerton, 2012). As Alan Warde significantly observes,

> "consumption is not itself a practice but is, rather, a moment in almost every practice" (Warde, 2005:137).

Whilst practice theories have been adapted for application to specific empirical research fields – each domain representing its own assemblages of knowledge, concepts and discussions, theoretical research distinctly understands social practices as multi-relational configurations that place the social in the performance of practices (Halkier & Jensen, 2008). Rather than dominant knowledge, policy and programmes that place human minds and/or technological solutions at the forefront of social order, SPT never reduces what people do to a matter of individual attitudes or choices, but always understands doings as the performance of a practice (Halkier & Jensen, 2008).

Therefore SPT departs from dominant human-centred psychological and economic theories that Elizabeth Shove terms the 'Attitudes, Behaviour, Choice' (ABC) model (Shove, 2010). This ABC-paradigm refers to typically restricted modes and concepts of social change that are embedded in contemporary policy approaches, and that frame human action primarily as a matter of individual choice, and behaviours as an outcome of peoples' attitudes (Shove, 2010). Confronting the limitations that these dominant approaches have when considering how society will transition towards sustainable resource consumption, SPT provides a potential alternative socio-technical change approach (Hargreaves, 2011; Shove, 2010; Shove et al., 2012; Strengers and Maller, 2014; Røpke, 2009; Watson, 2012). In this regard, Yolande Strengers (2012) declares social practices theories 'distinct social ontology', as they

> "depart from accounts that privilege social totality (social norms), institutions or systems (structure), cultural symbols and meanings (symbolism), or attitudes, behaviours and choices" (Strengers, 2012:226).

The alternative change mechanisms that SPT provides offer new ways of conceptualising the sustainability challenge, by going beyond technological fixes and behaviour change in the pursuit of sustainability and instead focusing on the dynamics and relations of social practices (Spurling & McMeekin, 2014).

5.2 THE DYNAMICS OF SOCIAL PRACTICES

The ontological unit of analysis within SPT, as applied to sustainable consumption research, typically refers to 'practices' in terms of domestic 'doings', such as 'showering', 'cooking', 'working', 'shopping', 'driving', which constitute everyday life. Here SPT is concerned with capturing the dynamic aspects of social practices in order to explain change, stability, novelty, and persistence in the social order of societies, and therefore the aim to understand how practices emerge, evolve and disappear as part of everyday life. Significantly, focusing on practices bridges overcomes the structure-actor gap, or the classical dualisms in sociological theory between 'structures' and 'agency'. Inspired by Anthony Giddens' structuration-theory (Giddens, 1984), SPT attempts to understand the changing contours in social practices as an outcome of the duality between agency and structure (Shove et al., 2012:3). By taking practices as the unit of analysis, the co-constructive relationship between socio-technical structures and human action can be understood.

Schatzki identifies two central notions of practice: practice as a coordinated entity and practice as performance in order to account for the recursive dynamics of structuration (Schatzki, 1996:89-90). This important analytical distinction between 'practice-as-performance' and 'practice-as-entity' indicates the inherent association and constitution between the two terms. As Warde argues,

> "Practices are thus coordinated entities but also require performance for their existence. A performance presupposes a practice" (Warde, 2005:134).

Whereas practice entities depend on repeated performances to be sustained, entities also order performances, providing potential opportunities for the composition of practices to change, as well as the links between practices e.g. in the mobility system, across time and space (Shove et al., 2012). As Southerton and McMeekin (2012) emphasise, practice-based approaches represent the 'meso-level' constructed by relatively stable elements that configure entities of blocks and patterns of action ('the macro level'), and reproduction and production of performances of practices or 'doings' in the daily life ('the micro level'). Recursive interactions between entities and performances produce the dynamics of reproduction and change (McMeekin & Southerton, 2012:350).

Regarding the practice of car driving, 'driving-as-entity' refers to the recognisable conjunction of elements, which can be spoken about as a set of resources that are required to drive a vehicle. However, car driving also consists of performances, the accumulation of particular incidences of doings. Thus, 'driving-as-performances' are the observable doings of particular individuals often referred to as 'behaviours'. In this regard, car drivers are 'carriers' (Reckwitz, 2002) of particular mobility practices, that reinforce, reproduce and potentially change, current mobility patterns (Shove et al., 2012). It is through the cumulative moments of performance, the 'pattern' provided by the driving-as-entity is filled out and reproduced. Hence, interdependencies between the elements lead to the practice being sustained over time (Watson, 2012).

5.2.1 CONFIGURATIONS OF PRACTICES

As an effect of the heterogeneous approaches within SPT, the units configuring a social practice have been variously interpreted (Gram-Hanssen, 2011). Schatzki defines a practice as a "temporally unfolding and spatially dispersed nexus of doings and sayings" held together by three elements: 1) shared understandings 2) explicit rules and 3) teleo-affective structures' - the 'ends, projects and tasks' associated with moods and emotions (1996:80,89). These blocks or patterns of activity are filled out and enacted by practitioners who through performances of particular 'doings' reproduce, transform and perpetuate the practices they carry. The distinctiveness and potential of SPT is made clear by Reckwitz's (2002) definition of a practice as

> ”a routinized type of behavior which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, ‘things’ and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge” (Reckwitz, 2002:249).

In 2005, Shove and Pantzar reduce the elements of a practice to three: competences, meaning and products. Further, Shove et al., (2012) elaborate the idea that

> “practices are defined by interdependent relations between materials, competences and meanings” (Shove et al., 2012:24).

They further describe these elements as,

> “materials – including things, technologies, tangible physical entities, and the stuff of which objects are made; competences – which encompasses skill, know-how and technique; and meanings – in which we include symbolic meanings, ideas and aspirations” (Shove et al., 2012:14).

Whilst such three elements form a simplified and abstracted understanding of practice, I found this conceptualisation useful. Hence, driving practices entail the involvement of some physical ‘materials’, ‘competences’, and ‘meanings’, as reflected in the routinised and embodied daily performance of driving. Through driving, the ‘carriers’, ‘practitioners’ or ‘drivers’ engage different links between these elements, and in this way, they reproduce and change the dynamics of collectively shared driving/ mobility practices (Shove et al., 2012:8). Reproduction and change in practice are developed by practitioners’ doings and their willingness to integrate and link the different elements. In this regard, practices change when new or existing elements are combined in a new way. At the same time the elements are themselves outcomes of the practice and its performance.

Warde states that the sources of changed behaviour are developed in practices themselves, and as such SPT has the capacity to account for both reproduction and innovation (Warde, 2005:140). Despite change and continuity being regarded as an outcome of the integration of elements, SPT suggests the researcher is responsible for identifying elements from the practices of which they are a part. At the same time the analytical approach emphasize a need for the researcher to be aware of

> “the trajectories of the elements, and to the making and breaking of links between them” (Shove et al., 2012:22).

Moreover SPT states that all practices are internally differentiated, such that persons in different situations do the same activity differently (Warde, 2005:146). In particular what differs SPT from other social and cultural theories is its involvement of materials within configurations of social practices. Emphasising the material as a significant dimension of practices reflects the impetus of Actor-Network Theory, to a high degree. As previous examined, Callon emphasised car users' rejection of EVs and continued preference for the traditionally motorcar, for a whole series of reasons, of which one related to the material of poisonous catalysts. This perspective, which draws attention to an often over-looked material component of driving, highlights how use of traditional sociological frameworks can simplify and abstract social reality (Callon, 2012:91).

Shove and Walker (2014) argue that recognising material arrangements as part of the constitution of practice, including forms of energy, is crucial for understanding sets of enacted, reproduced and transformed practices in society (Shove & Walker, 2014:48). They suggest,

> "that energy supply and demand are realized through artefacts and infrastructures that constitute and that are in turn woven into bundles and complexes of social practices" (ibid:42),

and contend that it is vital to remember that material arrangements are themselves made, reproduced and transformed through and as part of happening practices (Shove & Walker, 2014:51). Whilst ANT acknowledges materials as a major player in socio-technical change and stability, SPT theorists criticises ANT for being too deterministic about the agency of materials and the influence of 'doings' (Shove et al., 2012:9). Nevertheless, Shove et al. acknowledge that the provision of new 'infrastructure', and intervention in existing infrastructural 'arrangements', is essential in order to attempt to change current car dependent practices (Shove et al., 2015).

5.2.2 CHANGE AND CONTINUITY

How practices are reconfigured and change across different times and spaces, with implications for resource demand and consumption, is a matter of continuous deliberation within SPT. Reflecting the energy transition and smart grid discussion, SPT theorists hold that households are more than consumers, and should therefore be considered as 'practitioners' or 'co-managers' who are implicated in the routine functioning of the socio-technical system as a whole (Shove & Chappells, 2001:57). In particular, when considering the energy system, SPT theorists point to energy's 'invisible' aspects (Hargreaves et al., 2010). Thus, SPT theorists point out that sustainable consumption and smart grid development has to acknowledge that innovation needs to become embedded in daily life (Shove et al., 2007). In light of this, Strengers' book on smart techno-utopia calls for increasing SPT-based research to be conducted on how best to attempt to accomplish smart grid transitions (Strengers, 2013).

Focusing on the collective aspects of consumption and the complex dynamics of socio-technical reconfiguration, some recurring research questions include: How do social practices emerge and change through new links and elements? How are routines and embodied habits implicated in the practices of (EV) driving? What characterises the recursive relationship between time shifting consumption and new routines? What factors increase householders' engagement in and motivation to change their energy consumption? How are elements held together in a whole range of practices and as a part of different practices? How are practices linked, intertwined, generated and reproduced, and how do they persist and disappear? How can we avoid developing negative side-effects and new unsustainable practices? To what degree is the element of meaning needed to challenge powerful conceptualisations associated with resource-intensive conventional (driving) practices? These questions are elaborated in the following discussion (cf. section 6).

5.2.3 RECONCEPTUALISING SOCIO-TECHNICAL CHANGE

Given the continuing acceleration of energy intensive practices, present governance approaches that focus on developing and disseminating technological solutions, and attempts to increase consumer pro-environmental behaviour, are not sufficiently effective to bring about urgently required socio-technical change. Reviews of EV adoption and smart grid interventions promote a widely accepted vision of EV users and future technology adopters' as 'smart' and flexible micro-generators that are able to perfectly integrate smart technologies into their homes. These approaches rely on individuals making voluntary conscious decisions and making rational choices about changes to their everyday lives. Distinct to these techno-rational approaches, social practice theory (SPT) decentralises technologies and the individual from practices by, for example, focusing on resource and energy use as artefacts of practices that are configured, reproduced and potentially changed through ongoing interactions between practice elements in time and space.

In line with this argument, Yolande Strengers' book, 'Smart Energy Technologies in Everyday Life: Smart Utopia?' (2013), shares several similarities with the conceptual and analytical approaches adopted in this PhD. By suggesting what is needed is a ‘reimagining’ of the ‘smart’ vision, Strengers advocates for

> “an alternative ontology of everyday practice to understand how smart technologies and the energies they manifest are being integrated into everyday life, where they are involved in performing and transforming everyday routines” (Strengers, 2013:155-156).

Strengers is concerned about utilities, governments, researchers and other businesses continued focus on ‘learning’ consumers’ rationally informed and measured energy consumption and management. She suggests that this approach overlooks academic critiques of the rational consumer, undermines how practical knowledge is important for managing energy in peoples’ everyday lives, and assumes an optimistic relationship between energy providers and consumers. Hence, she suggested that it is time to “put Resource Man and his associated tools to bed” (ibid:157) and to disrupt the dominant policy and research agenda by reimagining a Smart Utopia that is grounded in the mundane realities of everyday life. She suggests that this demands an

> “ontology of everyday practice [that] proposes that change takes place in and through householders’ participation in everyday practices” (Strengers, 2013:159).

She therefore argues that we need to acknowledge smart energy technologies as part of practice performances (Strengers, 2013:64). My research outcomes have several overlaps with Strengers’ findings, as described in the later discussion of my papers.

5.3 GOVERNING SOCIAL PRACTICES

SPT-based research approaches have been occupied with describing the repetition and reproduction of social practices, but have been criticised for struggling to explain change and innovation in practices (Geels, 2010). In response to these critiques, an increasing number of practice-based empirical analyses attempt to illuminate change and stability in practices, by incorporating inspiration from transition theory research, such as the Multi-Level Perspective (MLP). My stay as an exchange student in the research group Science, Society and Sustainability (3S) at the University of East Anglia (UK), gave me insight into some recent practice-based contributions that examine how to achieve the required radical change of unsustainable practices. Overall, these contributions seek to understand and provide recommendations as to how best to govern social practices to achieve sustainable socio-technical transitions.

As illuminated in paper IV, Watson's 'systems of practice' approach (2012) provided me with an alternative explanation of the low EV adoption rate and the limited realisation of EVs' smart grid potential. The 'systems of practice' approach framed mobility interventions in terms of acknowledging interactions between different driving practices and their recursive interrelations with wider systems of practices. In addition, Spurling and McMeekin's (2014) three intervention framings were used to understand strategic interventions in mobility practices. In line with Strengers' work, paper IV demonstrates how EV adoption and future smart grid interventions would benefit by exchanging or supplementing their one-dimensional focus on technological solutions and pro-environmental behaviour change, with a more complex, and accurate, systems of practice approach. Thus, this paper acknowledges the need for innovative governance incentives that recognise the path-dependency of current systems of practices, and deliberately intervene in the interlocked systems of practices, of which driving is a part.

In addition to Watson's articulation of SPT-informed socio-technical systemic approaches, other researchers have put forward the valuable potential of studying the intersections and crossovers between social practice theory and the MLP (Gram-Hanssen, 2011; Hargreaves et al., 2013:201; McMeekin & Southerton, 2012). Through empirical analysis of two different case studies of sustainability innovation, Hargreaves et al. argue that

> "intersection between regimes and practices offers vital insights into processes that can serve to hinder (or potentially help) sustainability transitions" (Hargreaves et al., 2013:403).

Their distinctive 'up, down, round and round' conceptual framework suggests not integrating the distinctive strengths of the two theoretical frameworks, but rather they suggest that a more thorough understanding of sustainable innovation processes is provided by retaining the distinction between regimes and practices, and exploring how they intersect and overlap.

Southerton and McMeekin (2012), also recognise a need for stimulating the dialogue between the MLP and SPT researchers, as they argue that,

> "So far, the application of practice approaches to sustainability transitions has largely focused on final consumption and changes in what people do in their everyday lives; there has been no equivalent

> analysis of changes in the organisation of production (…). By contrast, the MLP has paid very little attention to final consumption and remains an approach that foregrounds the importance of technological change" (Southerton and McMeekin, 2012:353).

Thus, they emphasise that this 'dialogue' could provide pivotal and thorough impetus for sustainable transition. Southerton and McMeekin argue that the MLP's hierarchical framework privileges the position of technology in the account of regime shift, and that its focus on central producers' development of radical innovations undermines studies of end-users and final consumption, which, they stress, represent the core target intended to absorb innovations and products. On the other hand, they simultaneously stress that practice-based approaches could gain from acknowledging the rationales pertinent to the production side.

Given these acknowledgements, Southerton and McMeekin (2012) suggest three significant forms of interaction between MLP and SPT that require greater conceptual and empirical attention in order to advance understandings and prospects for socio-technical transition. First, they highlight the need to take seriously 'the dynamics of social relations in final consumption', and to look at the conventions and norms that generate similarities and differences in the performance of practices between social groups. Here, Bourdieu's account of social differentiation that emphasises power relations and distinctions between social groups can provide the MLP with different types of users, which are essential in order to comprehend how innovations will impact on a range of activities in daily life, and not just those specific to certain initiatives or technologies (ibid:354-355). Second, they highlight how more conceptual work is required on the co-dependency of changes in production and consumption, because

> "sustainability transitions necessarily require change[s] in products, infrastructures, manufacturing processes and in the manner in which goods are used in the course of performing practices" (McMeekin & Southerton, 2012:356).

Hence, regime changes require a much stronger coordination and dependency between producers and consumers.

Third, the authors highlight the need to think beyond how consumers interact with technologies, to how new products and infrastructures interact with and affect practices. This requires further exploration of how technologies are intertwined with practices and consumption. They highlight the importance of understanding how technologies are absorbed into everyday ways of living, and not least how technological scripts can be powerful, and simultaneously can be inappropriately used and can have unintended effects (Southerton and McMeekin, 2012:357). In my study, I found several unintended negative feedback effects of the TEV trial such as; increased driving, extra use of electricity-consuming equipment, charging vehicles in peak hours, which is further elaborated upon in the following section. However, this inquiry concentrates on understanding innovation and change in the everyday 'doings' of households, whereas Southerton and McMeekin highlight how analysing changes and innovations in production are also essential for socio-technical transition. In addition, this enquiry to some degree also attempts to examine production-side practices in the analyse of the TEV intervention design.

Schatzki's (2012) interpretation of SPT as founded on a flat ontology, without any hierarchical governance structures, makes it difficult to identify how to actually govern social practices. Recently SPT-based research likewise avoids traditional top-down governance approaches, where socio-technical change is steered by powerful governors. To some extent Watson attempts to identify the role of power in practice, when he states that current patterns of resource-intensive personal mobility are constituted and reproduced by travellers' practice performances, but are also embedded in systems of power and interest (Watson, 2012:495). In contending that socio-technical systems are comprised of continuously dynamic practices, he argues that all practices whether performed in the home or in government offices, recruit carriers. Nevertheless he recognises some hierarchy in the production of practices. He describes how,

> "all the links, flows and processes comprising a system have to start and end in locales where those processes are initiated and made sense of through the performance of practices (...). Practices in these locales may often be a more effective target of intervention to effect systemic change" (Watson, 2012:496).

A further conceptualisation of socio-technical change is provided by Shove, Watson and Spurling's recent contribution on car dependency (Shove et al., 2015), which illustrates how socio-technical change (e.g. car driving) can develop independent to top-down governance approaches. This study illustrates how car driving and car dependency result from a variety of different everyday activities that are dependent on the social role of material infrastructures, and how these spatially extensive networks help to reproduce associated systems of practices and *vice versa*. Hence, the article's focus is on the relation between infrastructures and the various practices to which they relate (Shove et al., 2015:5). In particular they suggest that, 'infrastructure' has a special status and an inherent agency in the distribution of social practices, which is why this particular 'material arrangement' is pivotal for understanding the change and stability of mobility systems. Related to questions concerning the governance of practices, they emphasise how people involved in policy and planning are themselves enmeshed in a maelstrom of practice dynamics. They further state that,

> "It is tempting to conclude that professionals and policy-makers who influence infrastructural provision have some privileged status in steering what people do (…). Instead, we consider methods of planning and policy-making as practices in their own right, and as arrangements that are part of rather than outside the ongoing flux of daily life" (Shove et al., 2015:11).

In other words the governance of practices is conceptualised as a social practice itself.

Overall, the above contributions fail to be specific about how we might change and appropriately intervene in current resource-intensive (mobility) practices. In light of the urgent need for sustainable socio-technical change, is seems appropriate to identify how best to intervene in interrelated bundles and complexes of multiple systemic practices. Instead of giving all practitioners the same ontological and power status, the time has come to discuss and identify whom, where, when and how we should attempt to change and intervene in current unsustainable practices. Significantly, this calls for a new definition of a 'smart' utopia, which requires a redefinition and reconstruction of existing 'norms' and 'meanings' associated with everyday life.

6. DISCUSSION OF PAPERS

This chapter provides an overview of the key findings developed in the four papers making-up this thesis. The basis of the discussion is structured by the research question presented the introduction. In addition, I introduce supplementary research findings, and examine the need to develop a more precise suggestion about how to govern practices for a less energy-intensive transport sector. The section ends by reflecting on additional topics that could inform future research on the integration of smart grid technologies within everyday domestic life.

6.1 THE NEED TO REDEFINE ‘SMART’

Responding to the first research question; *what characterises mainstream assumptions informing the integration of households within the smart grid?* this investigation is concerned about the dominant vision of that peak electricity demand challenges can be solved by through development of smart information and communication technologies (ICT) alone (Hargreaves et al., 2015; Nyborg & Røpke, 2011; Strengers, 2013). This techno-rational paradigm anticipates that new possibilities developing in ICTs will be the core drivers for achieving a ‘renewable revolution’ at all levels of the electricity system; across electricity production, distribution and consumption. The review of Danish smart grid demonstration projects (cf. paper I) illuminates how mainstream approaches to electricity demand-side management can be divided into two different perspectives on the role of the consumer within the smart grid. The first and dominant perspective seeks to develop smart, automated technologies to control demand-side electricity consumption, which require very limited consumer participation. The second approach assumes that flexibility in demand management can be achieved through provision of economic incentives and consumer engagement. Additionally, a review of current literature and policy approaches confirms that such a one-dimensional focus on how techno-rational economic and psychological-oriented incentives can disseminate EV technology, dominates the research and development agenda worldwide. EVs’ ability to peak-shave and store electricity, thereby reducing the world’s dependence on fossil fuels, is assumed to occur through technological innovation and by educating consumers to adopt more pro-environmental behaviours.

My study of EV-mobility in operation reveals the insufficiency of these dominant techno-rational assumptions, and responds to the second research question; *what* *characterises the electric mobility operator's (EMOs) intervention in households' social practices?* This study confirms that the smart grid operator expected that flexibility and change amongst consumers would occur through technological innovation, economic incentives, and by educating consumers to adopt more pro-environmental behaviours. The combined test-trial (EVs + time-of-use pricing) illustrates how operators' assumptions about how demand-management would be accomplished, relate to both automated control managed by smart technologies, and the active involvement of consumers in responding to economic-incentives. Clever installed intelligent timers in the load boxes to automate and manage load-management centrally, and at the same time they sought to educate the participants about green driving techniques, the need for environmental-friendly peak-shaving, and the possibility for making economic savings. They also tried to encourage householder commitment by emphasising the uniqueness of the combined trial. These comprehensive attempts to increase flexibility in household practices, indicates Clever's openness to a wider concept of change than that of a one-dimensional technological fix alone. Nevertheless, the operator reproduced mainstream research and policy approaches by considering technological innovation and economic incentives as fundamental for bringing about socio-technical change. Essentially, the operator concluded that smart grid adoption is dependent upon making EVs economical and technologically competitive compared to conventional combustion cars.

At first glance, the operators' approach could appear correct. As illuminated, the operator's approach appeared to increase the flexibility of participants in the combined test-project. The participants in the test-trial postponed their electricity consumption practices to low-demand periods during the night, which indicated a high peak-shaving and flexibility potential. The project owners interpreted this willingness to postpone in terms of householders receipt of; economic incentives, information, and education intended to increase their pro-environmental consciousness. Despite my empirical material confirming that economic incentives and participatory engagement do (to some degree) influence flexibility, my practice-based analysis elucidated how everyday household energy-consumption is enmeshed in multiple 'invisible', 'unconscious', and 'irrational' performances of social practices.

However 'smart flexible energy consumption' is accommodated – through passive or actively engaged householders, this inquiry illustrates the risks of neglecting the synchronisation and persistence of habits and routines, and the more critical risk that technology-centred designs will result in the unintended consequences of reinforcing comfort and energy consumption practices. Through in-depth investigations of households' social practices, this research illuminates that 'smart' is not really smart if the development does not recognise the complex patterns of peoples' social practices through which energy consumption occurs. Therefore decarbonisation and the transition to a low-carbon society must recognise the dynamics of social practices in order to attempt to change them. Interventions must also acknowledge how temporally changing practices (time shifting) is a more complex affair than conventional techno-rational frameworks acknowledge. The following examination clarifies how practice-based approaches provide comprehension of the interplay between smart grid technologies and invisible and inconspicuous electricity consumption occurring throughout everyday life.

6.2 'SMART' IS A FOCUS ON PRACTICES

The third research question was; *how does a social practice-based analytical approach provide essential alternative knowledge for integrating smart grid technologies within everyday domestic life?* Despite drawing on different frameworks, this question is addressed by all of the four papers. A SPT-based approach provides a useful conceptualisation of the elements configuring social practices, which goes beyond a focus on the time shifting and driving patterns that were identified among the households participating in the test-trial. Through the conjunction of four practice elements; 1) engagement, 2) technologies, 3) know-how and embodied habits, and 4) institutionalised knowledge and explicit rules (Gram-Hanssen, 2011), I observed how households' existing electricity-consumption practices changed with the formation of new links and interrelations between elements (cf. paper II based on qualitative interviews with participants in the combined test-trial).

As part of this research question, I sought to understand; *how smart grid technologies interplay with households' everyday routines and habits?* Analysis identified that the elements of EV-driving comprised the particular 'technology', which not surprisingly was consistently compared to the householders' conventional cars. For parameters such as design, comfort and acceleration, the cars were experienced as competitive, while purchase price was considered as being too high and driving range was thought to be too limited. Further, the element of 'know-how & embodied habits' of electric driving was comparable to conventional driving, although some new (more economic/sustainable) driving techniques were adopted, as inspired by the batteries' reduced noise and sensitivity aspects (these, features also increased householders' feelings of uncertainty). The enquiry revealed that 'institutionalised knowledge and explicit rules' and 'engagement' had crucial impacts, because this group of 'testpilots' largely followed the institutionally outlined scripts and explicit rules about charging the EVs during the night, using the quick-charge stations (for free), and blogging every week about their experiences of being an EV test-driver.

The practice-based analysis made it possible to identify several links and correlations. For example, the link between the electric engines (technology), more energy-friendly driving (know-how and embodied habits), and improved awareness of other road users (given the lack of sound produced by EVs) were recognised. More energy-friendly driving techniques also decreased the use of technical equipment, such as air-conditioning and the radio during driving. The easy ‘plug-in’ routine was linked to the motivation (engagement) to follow the ‘rules’ set for the trial

The operators’ framing of environmental driving techniques, EVs’ peak-shaving potentials, and the announcement of the extraordinary due to the combined trials of TEV and time-of-use pricing influenced the testpilots’ willingness to time shift their energy-consuming practices. This illustrates how the ‘EV-driving-as-entity’ had a pivotal impact on the ‘EV-driving-as-performance’. In particular, the enquiry highlights how the strong link between ‘engagement’ and ‘institutionalised knowledge and explicit rules’ had a crucial impact on households’ time shifting (cf. paper II). As revealed, all participants found it meaningful to follow the ‘rules’ of the trials, and therefore they commonly experienced newly adopted routines and habits (such as emptying the dish washer and hanging up the wet laundry in the mornings) as inconvenient and stressful. This indicates how the motivation to time shift was tightly linked to participants’ feeling obliged to adhere to the ‘rules’ of participation during the test-period. Another crucial finding that deserves elaboration is the operator’s conclusion that the test-sample had a high preference for automatic load-management instead of manual load-management. Considering the technical bugs associated with the load-boxes (cf. section 3.2), this conclusion appears misleading. All my interviewees declared problems resulting from the manual installation of the timers. Householders’ associated experiences of empty EV batteries in the mornings were experienced as completely non-acceptable, and a number of householders were relieved to hand control for EV-charging over to Clever. In general, the operator’s positive conclusions and perceived successes about the dual trials’ huge potential to time- shift household practices through economic incentives, seems too optimistic. My empirical material instead demonstrates that the load-equipment (beta-version) was deficient and therefore not very ‘smart’ from an everyday perspective. Rather, ‘smart’ is when the socio-technical change intervention takes into consideration the reconfiguration of households’ multiple social practices In the following, it is argued that ‘smart’ grid development crucially needs to be aware of the essential ‘synchronicities’ that occur between practices, and how these overlaps and interactions sometimes can lead to unintended governance consequences.

6.3 SYNCHRONISATION

As part of research question three, I acknowledge ‘synchronisation’ to be important for recognising and potentially intervening in the dynamics of practices. The analysis (cf. paper III) demonstrates how the newly formed electricity consumption-peak (occurring during the night), is part of, and tightly connected to, multiple ‘temporalities of practices’ in the householders’ everyday lives. Hence, the analytical question was: *[h]ow does time shifting change and reconfigure households’ social practices?* In general, ‘synchronisation’ between the temporality of practices is recognised as one of the crucial corner stones for integrating smart grid technologies and new energy consumption patterns into everyday life. Drawing on particular conceptualisations from Walker (Walker, 2014) and Southerton (Southerton, 2003, 2009, 2012), we identified four sub-categorisations of the term, which each seemed fundamental for understanding households’ flexibility to time shift. The four identified analytical foci included: 1) ‘synchronisation’ between practices, referring both to the relationship between *existing* practices, between *existing* and *ne*w practices, and between *new* practices, as determined by smart energy technologies, 2) ‘synchronisation’ between collective and institutional rhythms and final consumption patterns, 3) ‘synchronisation’ between smart grid technologies, and finally 4) ‘synchronisation’ between natural and societal rhythms. Crucially, these sub-categories are not independent categories of processes, objects and elements, but were rather identified by observing the tensions occurring due to interactions between households and smart grid technologies.

First, the ‘semi-automated’ technologies had time shifting potentials due to their ability to run independently of the practitioners’ direct bodily interventions, but they simultaneously challenged the ‘temporality of practices’, in particular first thing in the morning. Reflecting significant SPT-research contributions (Shove et al., 2012; Southerton, 2012; Strengers, 2013; Walker, 2014), I discovered how energy-consuming practices are interwoven with different everyday practices. Counter to dominant smart visions however, my analysis illuminated how time shifting has consequences for a whole structure of other related practices, and perhaps most challenging are threats to the qualitative ‘cold-spots’ in households’ time-pressured mornings (Nicholls & Strengers, 2015; Southerton, 2012). I demonstrated how new links between elements can transform entire bundles or complexes of social practices within households. At the same time, several participants experienced 'inconvenience' and 'stressfulness' related to interactions between practitioner and technologies in accordance with these new temporalities (e.g. loading/ unloading the washing and dishwashing machines).

These 'coupling constraints' (Hägerstrand, 1985) challenged conventions of 'convenience', related to household practitioners' control over the temporal organisation of their daily practices (Shove, 2003:170). This exemplifies how smart grid interventions can contest existing practices. Interviewees' stories about unexpected incidents, for example the failure of EV-charging and unpredictable weather conditions, furthermore illustrates how time shifting requirements brought frustrations as they disturbed householders' tightly planned schedules. In addition, the real-time pricing scheme was experienced as too time demanding for all of the interviewed households, and the complication created by checking it almost created a practice in its own right, instead of being a guiding scheme. Similarly, Strengers illuminates that a narrow focus on measuring 'energy feedback' in kWh has limited potential to deliver changes in demand management, because numbers and kWh are not an important and necessary part of most domestic practices performances (Strengers, 2013:92). Compared to real-time pricing, variable network tariffs delivered far greater benefits because of their simplicity, and potentials associated with time shifting the temporality of particular domestic practices. However, households' abilities to time shift and their flexibility in adjusting the temporality of their practices were not homogeneous. As demonstrated, the degree of flexibility varied according to households' dispositions (Southerton, 2012). This is another very significant finding, elaborated upon in section 6.7.2.

Second, disruption to daily schedules relates to a tension between households' management of certain spatio-temporally fixed and institutionalised events (e.g. meals, work and school times) and 'cramming' activities into self-designated temporal 'hot spots' in order to free up 'cold spots' of household togetherness at other times (Southerton, 2003, 2012). Interviewees expressed challenges related to having to squeeze additional activities into weekday morning 'hot spots', which were already performed within limited time periods, intense in the number of performed activities, and often involving multi-tasking. For most of the households, hanging wet clothes up to dry in the morning challenged cherished family times, like being together around the breakfast table. This illustrated how 'cold spots' of quality time', form antitheses to 'hot spots' which are tightly constrained into specific temporalities, and tend not to be sacrificed over the performance of housekeeping related activities, such as hanging-up clothes or emptying the dish-washer. We acknowledge how 'cold spots' are embedded within 'hot spots', blurring the distinction between 'hot spots' and 'cold spots' as distinctly different temporalities of everyday life. For example, the collective 'ritual' of eating breakfast or dinner together were not possible for many participant households to reschedule.

We highlight how existing collective and institutional rhythms are critical to households' flexibility in changing the temporal dynamics of their daily practices (Southerton, 2012; Walker, 2014). Some daily practices (like preparing dinner and showering) are so closely related to institutional rhythms (like work and school hours) that they are considered not to be open to time shifting. Dishwashing, laundering, and EV charging were found to be more flexible in terms of timings, due to aspects of semi-automatisation, and the decoupling of electricity consumption and bodily involvement (Powells et al., 2014). This indicates how 'breakfasting together' produces more meaning, and is therefore prioritised in terms of performance over other mundane practices. This results in a kind of 'hierarchy' in the performance and ordering of domestic practices.

Third, the new electricity consumption peak produced by the participants from the test-trial indicates that future demand-side strategies could benefit from combining interventions. When comparing these participants with participants from the focus groups (not subject to hourly pricing schemes), the motivation to time shift was almost absent. In addition, several participants declared that installing photovoltaics and producing one's own renewable electricity would increase the incentive to adopt an EV considerably. Here, several households found it commendable to be 'prosumers' in the future. Comparing participants 'sayings' and 'doings' illustrated how expressions of household engagement actually corresponded with the data obtained from the load profiles. Studying these 'doings' was also relevant for understanding whether participation in the trial produced a long-term effect.

Almost all participants in the double trial claimed that their increased consciousness about pro-environmental behaviour would persist into the future (i.e. after the trials had ended). Despite the load profiles indicating some long-term changes in time shifting, the load profiles from 2013 showed that these new electricity consumption patterns did not have significant persistence. In terms of the value of synchronising smart grid interventions, there is a strong indication that the encountered high flexibility in practices and participation rates were coupled to the element of technological innovation and testing. The fact that none of the participants wanted to buy or lease an EV at the project's conclusion illustrates the gap between claimed pro-environmental behaviours and realised domestication and actual adoption of this new technology ('value-action gap', see Barr, 2006). In terms of more energy-efficient driving practices, it is anticipated that this performance also expires when participants cease their involvement in the trial. Consequently, the link between participant engagement and know-how about how to extend the capacity of the EV battery, possibly disappeared when the trial ended.

Fourth, this research highlights the dependence of smart grid interventions on natural externalities, reinforcing Walker's observation about the need to reinstate acknowledgement of the synchronicity between electricity demand and natural forces producing renewable energy (Walker, 2014). Rather than simply focusing on changing the actions of individuals, synchronisation between electricity production and consumption necessitates smart grid initiatives recognising the temporal complexity of practices. For example, the test-participants' experienced changing weather conditions as very disruptive to their tightly packed daily schedules. Thus, these natural forces induced stress and frustration within the participating households.

The EVs' sensitive electric engines were experienced as very dependent upon external forces, such as temperature and wind, which increased participants' uncertainties when EV driving. This effect was particularly pronounced amongst the winter testpilots, who, in general, were far more negative about the competitiveness of EVs. As such, interrelations between uncontrollable natural forces and smart grid technologies appears to be one of the core thresholds necessary to negotiate, in order to integrate smart grid solutions into everyday life. This indicates that participants' perceptions of integrating dynamic tariffs and EVs into daily domestic activities, would have been more critical if the test-trial had run over the winter (e.g. hanging clothes up outside in minus conditions). Considering such 'social-natural synchronisation' (Walker, 2014), smart grid interventions require reliable solutions to increase participant engagement and to simultaneously not elevate time pressures and inconvenience within peoples', already time-pressed, daily lives.

In light of these findings, it is recommended that future smart grid interventions are convenient, reliable, predictable and not too demanding of time. This demonstrates how time shifting semi-automated practices decreases flexibility in everyday life, by challenging the synchronisation of existing practices, and synchronicities between existing and new practices. Further, empirical analysis illuminates how changes to the sequences of practice performance, can be facilitated through synchronisation with existing routines. For example, the plug-in practice (of EV charging) was easily routinised because it was coupled with the 'shut-down-the-house' routine that was commonly performed before going to sleep. In addition, it is possible to facilitate new practices involving multi-tasking if they can be performed in the same space; for example, unloading the dishwasher whilst being together with other family members in the kitchen area. Thus, the ability to bundle new activities together with existing daily routines, makes it easier for households to time shift their existing daily practices.

6.4 NEGATIVE UNINTENDED SIDE-EFFECTS

The SPT-based approach adopted in this research, has proved useful for revealing the unintended, unforeseen and unsustainable side-effects related to the integration of smart grid technologies within everyday life. Findings from the first set of empirical material (combined test-trial during the summer) illustrated that householders began to wash their clothes more frequently during the week, instead of dedicating Saturday for completing their laundry activities. Their increased dependence on the weather situation, which led to more frequently weekly washing, may prompt households to purchase a tumble dryer.

Findings from the winter test-drivers (without pricing schemes) critically revealed that participants recharged the EVs when they came home from work in the early evening, and thus charging coincided with the critical evening electricity demand peak occurring between 17:00 and 19:00. This was the most striking negative consequence observed, since this association challenged the assumption that households could act as innovative smart grid operators. This potentially supports the operators’ assumptions that economic incentives could be used to temporally (re)organise households’ energy-consuming practices.

Another significant ‘spin-off’ was that participants used electric heaters to warm the EV engines up to remove ice from the car windows on winter mornings. Furthermore, and common to both sample populations, analysis demonstrated that EV test-driving increased the perceived household need for a second car. This was produced by participants’ experiences of the increased comfort and convenience generated by having two cars in the family. Finally the introduction of an EV to participating households meant that bicycle rides and walking were commonly exchanged for rides in the EVs, and as such, the amount of driving trips increased during the test-period. This supports Shove’s observation that existing practices change with the circulation of new and different elements (Shove et al., 2012:73), and emphasises how new technologies can increase concepts of convenience, luxury and comfort (Nyborg & Røpke, 2011:1858; Strengers, 2013:158,51).

These examples of unintended consequences of the smart grid interventions, reveal how attempts to change consumers' behaviours and choices towards more climate-friendly alternatives, often fail to take into account how associated practice elements also change with the introduction of a new technology or product (McMeekin & Southerton, 2012:358). These examples highlight how smart grid interventions can result in 'un-intended' side-effects that undermine the systemic benefits that EVs can have on peak-shaving electricity demand and decarbonising the transport system. Overall, this demonstrates how dominant techno-rational approaches can have unsustainable negative consequences, and underscores the need for an alternative 'systems of practice' approach to both understand and intervene for sustainable transitions.

These findings share similarities with Strengers' SPT-informed analysis of 'home automatisation', in which she reveals that technologies intended to passively automate domestic practices, can serve to justify, and even increase, householders' energy demand expectations associated with smart technologies. For example, Strengers' analysis shows how assigning control to efficient and smart technologies increased households' requirements for; instant comfort, convenience, cleanliness and pleasure, leading to increased electricity-demanding expectations (Strengers, 2013:127). Referring to a study by Røpke and Christensen (2012), she argues,

> "[t]his ability to perform multiple practices at the same time presents new opportunities for energy to be consumed" (Strengers, 2013:127).

Concluding, Strengers strongly recommends that 'smart' energy initiatives acknowledge the meaning of comfort and pleasure, and that they focus on how smart technologies become meaningful to practices. She suggests that they should therefore be designed in combination with the temporal and spatial dimensions of everyday household practice performances and routines (Strengers, 2013:148,161).

These 'synchronisations' and 'negative side-effects' inform key findings of this thesis concerned with better designing and implementing future smart grid technologies. These empirical findings arose several times across the different papers, despite their different analytical foci, given the SPT-based framework. This underlines how the link between electricity production and consumption has never has been more crucial to recognise and understand. As such, this investigation recommends closer cooperation between the producers and operators of smart grid technologies and their final consumers living in private homes.

For example, knowledge that electric heaters are being used in the morning is useful for informing EV car manufactures and operators about whether to release the storage potential of EV batteries during the night. Instead of reproducing the dominant dichotomy between technology and behaviour, and framing efficiency gains as a matter of supply and demand, knowledge about social practices at the final consumption level has been shown to be fundamental for meeting urgent decarbonisation challenges. Looking beyond the EV technology, and considering how other elements configure practices, corresponds with Southerton and McMeekin's (2012) acknowledgement of the importance of looking into how new products are actually used and embedded within exiting practice nexuses (McMeekin & Southerton, 2012:358).

6.5 'SMART' IN SYSTEMS OF PRACTICE

From the first interview, EVs inappropriateness for meeting everyday household needs was evidently declared. Given the operator's positive framing of the EV technology as easily adoptable, this research discovered a clash between the meanings of producers and consumers as related to EV driving. There was a significant discrepancy between the positive rhetoric about 'EV-driving-as-entity' and the concrete experiences of 'EV-driving-as-performance'. In other words, the operators' attempts to change the 'meaning' of driving electric failed to gain ground.

When considering; *what characterises the operator's smart grid strategy for increasing EV adoption?* attempts to increase EV adoption were defined by attempts to change the 'meaning' of EV driving. The operator highlighted the 'green' and 'sustainable' aspects of EV-driving in terms of consumer 'responsibility' and 'consciousness'. To some extent the intervention therefore aimed to 'recraft' and 'substitute' unsustainable driving practices with a less energy-intensive alternative. However, at the same time, the intervention failed to consider how practices are 'interlocked', which this thesis acknowledges to be fundamental for encouraging lasting socio-technical transitions (Spurling and McMeekin, 2014).

As a part of research question four; *how can social practices be governed for sustainability?* this research proposes that green interventions and decarbonation strategies need to recognise the 'systems of practice' within which they operate. Smart grid technologies and interventions crucially need to acknowledge the recursive relationship between temporalities and practice. This reinforces the need for intervention designers to be cognisant of the synchronisation between social practices, collective and natural rhythms, and the close relationship between producers and consumers.

In paper IV, these conceptualisations go a step further. This article illuminates how EVs, framed as a climate-friendly technology, meet the nexus of social practices that are performed in everyday household life. From the beginning of my empirical insights, the paradox between non-adoption and smart grid operator's positive framing of EVs as able to meet everyday mobility needs, has been a recurring issue. As described in the literature review, this tension dominates the debate of EV adoption, both in research and development, as well as for international and national policy agendas. As for several other smart technology demonstration projects, my case study of an intervention in mobility concluded that the tested EVs were adoptable given their ability to cover participants' driving needs (cf. section 3). Moreover, at the end of the demonstration project, Clever confirmed that EV battery charging is easily routinised, EV engines operate reliably, that they have lower running costs compared with conventional cars, and that EVs have a high potential for electricity storage.

A 'systems of practice' approach explains the lack of momentum for EV-driving as a consequence of the social practices that are (re)produced by existing mobility needs and infrastructural arrangements. This approach contributes a more thorough explanation of the 'missing momentum' by empirically elucidating how practices relate and interlock within systems. Analysing the 'temporalities' of practice performance (paper III), was shown to be fundamental for undertaking a later analysis of the 'system of practice' associated with (EV) mobility (paper IV).

The analysis provided by paper IV recognises the need for understanding how links are developed and deployed, not just between elements of a single EV driving practice, or between two modes of practice (e.g. conventional *versus* EV driving), but also between multiple systemic practices. This shows how driving is connected with employment, social care, food-provisioning practices etc. In this regard, future interventions need a greater understanding of how the temporality of mobility practices intersect in wider systems of practice, to change the level, scale, and character of energy demand. Inspired by recent research (Shove et al., 2015; Shove & Walker, 2014; Spurling & McMeekin, 2014), this empirical case study acknowledges a need for new configurations of normality (routines and habits), and for bringing the 'negotiability of demand' to the political agenda. In order to alter the current conception of mobility, smart grid interventions need to reconfigure existing (related) practices either directly or indirectly. This brings to the fore, the need for further knowledge about how to govern everyday practices (such as driving) in less energy-intensive ways.

6.6 GOVERNANCE OF PRACTICES FOR SUSTAINABILITY

Addressing the sub-question that relates to question four; *how can a system of practice approach offer an appropriate concept for sustainable transition?*, this enquiry recognises the need to govern existing social practices for greater environmental sustainability. To release smart grids' anticipated decarbonisation potential, this thesis acknowledges the need for interventions that understand the interactions and recursive interrelations that driving and time shifting practices are subject to as part of wider systems of practices. Load-management and flexible time shifting will therefore only recruit and maintain practices and practitioners if the systems of practices, of which they are part, are identified and reconfigured.

To achieve this sustainable transition therefore involves redefining institutions that determine *when* practices take place and remaking the infrastructure to define *where* practices take place. Integrating EV driving as part of everyday life and time shifting domestic practices requires either; synchronicities between these new practices and with existing practices to be reinforced, or interventions that seek to de-synchronise the current temporalities of existing practices. My study reveals that the first generation of mass-produced EVs were incompatible with everyday life as long as other co-dependent practices were continuously performed. Consequently, smart grid interventions need to acknowledge the matrix of bundles and complexes of temporally dynamic practices. Smart grid initiatives and strategies also need to acknowledge the path-dependency of current systems of practices, of which EV car driving and time shifting form an increasing part. I discuss these significant findings throughout Paper IV and further in my conclusions.

As I illuminated in the previous theoretical chapter, several scholars (Gram-Hanssen, 2011; Hargreaves et al., 2013; McMeekin & Southerton, 2012; Watson, 2012) have suggested the need for encouraging dialogue between the multi-level perspective (MLP) and social practice theory (SPT) in order to provide thorough impetus for changing unsustainable socio-technical patterns. These contributions commonly oppose critiques that SPT has difficulties in accommodating radical socio-technical change (Watson, 2012), but give limited attention as to how to actually draw on the two theoretical frameworks to help inform the governance and change of environmentally unsustainable practices. Watson suggests to govern practices by,

> "understanding the systemic relations in which particular mobility practices are embedded, [through which] it should be possible to begin to identify possible points of intervention which set up positive feedback effects" (Watson, 2012). Hence, interventions only have real effect if they recognise, "the range of elements converging in a practice, and of the character of bundling and co-evolution between practices (…)" (Watson, 2012:494).

Watson suggests that small interventions, (for example, urban cycling training) may appear insignificant against the enormity of the decarbonisation challenge, but nevertheless have the potential to generate substantial cumulative effects on the overall system of transportation (ibid.). Further he emphasises how normalisation provides a fundamental feedback effect,

> "(…) the more that recruitment to cycling increases, the more normal it becomes to cycle, making further recruitment more likely" (Watson, 2012:495).

Nevertheless Watson's concept of governance is very abstract and difficult to localise, as he stresses,

> "[p]ractices recruit carriers in board rooms, the physical spaces of futures trading and government offices as much as they do on streets and in homes" (Watson, 2012:496).

According to this view, transformations in systems of practice can however also be initiated through bottom-up processes of self-organisation and self-extension. Critically though, this conceptualisation avoids localising how such processes can more concretely be governed and steered.

6.6.1 GOVERNING INFRASTRUCTURES AND ELEMENTS

Shove et al's (2015) recent study emphasises how car-driving practices, produced and coproduced by interactions within wider systems of practice, are, to a large degree, independent of top-down steering approaches, and rather govern each other through their mutual connections. Nonetheless, the authors point out that the 'arrangements' of material infrastructures are particularly powerful in terms of reproducing society's dependency on car mobility. Infrastructures have inherent agency in the distribution of social practices, which is why they are fundamental to interventions for accommodating sustainability. Unfortunately, Shove et al. do not suggest *how* to intervene in these arrangements or *how* to localise the recruitment of less-resource intensive practices.

At the same time the authors argue that people who are involved in policy and planning are enmeshed in a maelstrom of practice dynamics, and therefore they do not have a privileged status in steering what people do in their everyday lives. Because professionals and policy-makers are themselves part of these systemic practice arrangements, their governing practices are conceptualised as social practice in their own right (Shove et al., 2015). Whether change arises from small bottom-up initiatives at the community level, comes from the 'niche level' or is implemented through top-down regulations, the authors emphasise the arrangement of infrastructure as a powerful shaping force. Whilst this perspective recommends that decarbonisation strategies intervene in the infrastructural conduct of practices, Shove et al. are not clear about where and by whom such socio-technical change strategies should be governed.

Alternatively, Spurling and McMeekin's three approaches for practice-based interventions give policy and top-down governance approaches a spectacular status (Spurling & McMeekin, 2014). Drawing on these three practice-based policy intervention framings (cf. paper IV), I acknowledge that socio-technical transitions demand fundamental changes in (cultural) meanings. Changing 'meaning' affects norms and values related to; convenience, wellbeing, freedom, flexibility, mobility etc., and also brings new embodied skills and knowhow to the negotiating table. In this regard, it is important to call for greater policy guidance as to how to establish a change trajectory that synchronises and/or links together meaningful less-resource intensive practice performances together with new innovative technologies. In terms of my research, peak-shaving incentives require the provision of user-friendly technology, but also need to understand and relay why load-management is meaningful. This approach could, for example, highlight to consumers advantages, such as improved flexibility and increased availability of time produced by not having to use a petrol station to refuel, and/or the environmental and economic fortunes delivered by using electricity produced at home.

6.6.2 TOP-DOWN GOVERNANCE OF SMART GRID

Considering the above practice-based conceptualisations, my case-study of integrating EVs within everyday life and domesticating load management amongst final consumers represents a social practice in itself. Clever's intervention in household social practices, whether performed in the home or on the roads, reflects social practices, in which the operators are themselves enmeshed. Any type of intervention has some rationales, aims and objectives, and some tools that are assumed to address these goals. Distinct from recent practice-based approaches, I assign Clever (compared with, for example, the test-drivers) a more significant role in the governance of these social practices, not least due to their provision of charging stations and private equipment nation-wide.

Adopting a practice-based approach advocates changing from mainstream techno-fix and ABC governance approaches, which Clever partly reproduces. Problematically, SPT-based approaches to socio-technical change give very little attention to how to change governors' existing strategies and roles to attempts to implement alternative forms of governance (as are advocated by practice theoretical approaches). Given how current governance approaches, of techno-fix and ABC-aligned interventions, are struggling to increase EV adoption, it seems paradoxical to continue applying these approaches. Consequently, this research is concerned with whether the substitution of combustion cars with EVs will deliver more sustainable low-carbon practices, contributing to meeting the Danish Government's goal of the country being independent of fossil fuels by 2035. Clever's commercial agenda will not be able to fulfil this substantial socio-technical transition alone, and therefore I suggest that a more deliberate policy approach is required. As such, I argue that regulation and incentives are fundamental to achieving this transition.

Processes of top-down regulation and provision of incentives are acknowledged as essential to prompt greater EV adoption. As described by the literature review (cf. section XX), regulation and an increasing variety of incentives implemented by the Norwegian Government have proved critical for encouraging high market sales of EVs in Norway. In general, ambitious policy framings increase the 'meaning' of EV adoption, both according to realised economic benefits and the signalled value. Also, Figure 11 (cf. section 4.4.2) shows the relatively high sale of EVs (in particular Teslas) in Denmark prior to the tax exemption for EVs partly expiring in 2015. This indicates that governmental regulations, such as tax regulation, have a crucial impact on EV adoption. However, it is important to also emphasise that increasing EV adoption does not automatically lead to a decline in the sale of combustion cars, but rather may increase the total car population given that the EV may highlight a households' need for a second or even a third car.

Socio-technical transitions for sustainability require an explicit understanding of how to tackle power processes within systems of practice. Not least this enquiry highlights the need to negotiate of meaningful and less resource-intensive understandings of convenience, freedom and flexibility, alongside ensuring the implementation of ambitious governmental regulations and incentives. There is also a need to negotiate what type of society we wish to develop, as these ambitions are fundamental for changing current path-dependencies and highlighting the types of radical changes in everyday practices that are required (Hviid Jacobsen & Tester, 2012).

Governing practices at a municipal level also matter for socio-technical transitions. In the following, I briefly depict the Municipality of Copenhagen's ambitious targets, which underpin a comprehensive policy designed to recraft and substitute existing resource-intensive mobility patterns. Whilst this policy sets out a variety of ambitious intervention points, the following example stresses the importance of governance across the whole system of practice in order to achieve sustainability.

The 'Action Plan for Green Mobility', introduced by the Municipality of Copenhagen, provides an example of an ambitious mobility intervention. The action plan sought to 'normalise' cycling, by recruiting more cycling performances, and simultaneously modified infrastructural arrangements enhanced the 'meaning' of greener mobility performances.

Since 2012, several policy instruments have been implemented in order to make Copenhagen CO_2 neutral by 2025, as well as to reach the target of developing 'the world's leading cycling city' by 2015. To challenge resource-intensive mobility practices and provide sustainable alternatives, the interventions sought to increase public transport, cycling, and e-mobility, by improving collective transportation, providing better cycling facilities (e.g. widening cycling lanes, establishing green fast lanes, improving road surfaces) and installing EV charging facilities around the city. These initiatives have been coupled with action to decrease the benefits related to car driving (Copenhagen Municipality, 2012). Some initiatives to challenge car dependency have included; the provision of smaller roads, reducing the number of intensive traffic roads, increasing 'single-way' traffic regulation, regulating lower speed limits, and reducing car parking spaces and replacing them with EV charging stations. These governing practices demonstrate how political actions are intervening in existing infrastructures for sustainability. Simultaneously, several campaigns have been launched in order to highlight the 'meaning' of a healthier, easier, and greener lifestyle (Copenhagen Municipality, 2011).

Over the last decade, cycling in and across Copenhagen has significantly increased and there is greater car-sharing than ever before. As such, the municipality's multiple interventions have successfully increased sustainable mobility practices, which relates to Spurling and McMeekin's (2014) intervention type of 'recrafting' and 'substituting' policy framings. However, the amount of combustion cars is also still growing in Copenhagen, illustrating how car-dependent practices are linked to wider systems and infrastructures, and highlighting how such 'recrafting' and 'substituting' interventions cannot stand alone. Changing how practices interlock shifts attention to the need to intervene in wider 'systems of practice' and to change the normalisation of mobility demand. Thus, the final sub-question is adressed: *Do we need to bring 'negotiability of energy demand' onto the political agenda, and perhaps reconfigure the 'meaning' of mobility for the decarbonisation of society?*

6.6.3 RECONSTRUCTING MEANING

Though interventions need to recognise the interlocked systems of practices within which they operate, and how practice bundles and complexes change through interactions between constituent elements, there is still very little literature about the objects of governance, by whom and where governance occurs, and, not least, how some social practices 'govern' others. Given this oversight, it is essential to understand how to generate the 'right' interaction processes between practices, in order to path the way for greater uptake of less resource-intensive practices. This research suggests that to reduce the prevalence of unsustainable practices, requires the reconstruction of the meaning (of mobility) and changes to the 'normality' associated with developing a less resource-intensive system of practice. This brings to the fore questions about what constitutes 'the good life'. Today, limitless and accessible mobility, and the perceived freedom and happiness associated with this practice, has become a fundamental part of how society constructs 'the good life' (Freudendal-Pedersen, 2007).

Overall, this research suggests reducing expectations that innovative technologies alone will deliver the solution of radical change, and potentially even more important, it is necessary to reconceptualise how 'meaning' is brought into discussions about how to bring about socio-technical transition. To reconfigure 'meaning' within (driving and time shifting) practices there is a need to localise possible intervention points and identify; by whom, how, when and where powerful normalisations about 'the good life', which are shrouded in notions of individuality, flexibility and freedom, are generated and produced.

In this regard, Wolfgang Sachs' (1992) historical and cultural analysis of the motor car in Germany from the late 1880s, which describes how private motorisation became an intrusion, has been very inspiring reading. In his book, he examined how the automobile is much more that a means of transportation carried by technological innovation, and portrays the German 'love affair' with automobility as a journey of desires and dreams. As he stresses,

> "[t]his book, therefore, is an invitation to come on a journey back to the beginnings of our automotive needs, to where the breast first swelled with the pride of independence, where the love of speed was born, where the feeling of comfort took root, and where the automobile became allied with the clock as a 'time-saving machine'" (Sachs, 1992:viii).

The car's status, comfort and ownership were promoted by the car-manufacturing industry, through extensive marketing and advertisement. Sachs appeals for changes to normalisations, for example, so that 'tranquility' is rediscovered through a renewed love of the bicycle. He also calls for a policy of slower speeds and shorter routes of a moderate level, in an attempt to dismantle society's political and economic assumptions that are based on the automobile (Sachs, 1992:221). Like paper IV, Sachs suggests reframing what constitutes 'quality of life' without compromising quality, but instead making it more 'free and pleasant' to live in a less consumption-intensive society. Although a practice-based approach criticises deliberate attempts to modify preferences, dreams, and desires, and stresses how resource consumption is largely an unconscious artefact of behaviour, this thesis nevertheless calls for greater examination of the role of 'meaning' in consumption practices.

To decipher the construction of powerful normalisation processes emphasises how subject framings can help understand how to boost processes that govern social practices in less resource-intensive directions. Successful interventions hence to some degree require that producers and consumers operate with largely the same understandings of meaning about particular practice performances. In contrast, Paper IV attempts to illuminate divergent concepts of meaning that existed amongst test-drivers and the operator. This paper further suggests that examining the construction of meaning amongst consumers and producers would usefully benefit the development of adoptable and user-friendly smart grid technologies. As mentioned in the methodology (section 2.3.3) the production of meaning through social relations within the focus groups gave insight into how meaning (and power) is not static, but can be considered as a dynamic practice element that is (re)produced through the performance of social life. In addition, analysing construction of the meaning element at the macro level amongst key stake-holders and policy-makers, is suggested as essential to ensure smart and sustainable design that works in 'real life' households.

6.7 REFLECTIONS

In the following section, I introduce further significant reflections and perspectives. Despite some of the research areas departing from my research focus, these reflections have nevertheless come to the fore several times throughout the research process. Further, I argue that the following reflections could contribute crucial in-depth comprehensions concerning the interrelations between smart grid technologies and householders' everyday doings.

6.7.1 CAN PRIVATE SMART GRID INTERVENTIONS BE 'GREENED'?

Clever's smart grid operations developed several unsustainable side-effects. This underlines the complexity of socio-technic transitions and illustrates how such interventions struggle to manage and control change occurring in social environments. Simultaneously, the intervention assigns the operator a powerful position as potential change agents for sustainability. Through recruiting 1,578 households to the intervention and by using several participatory instruments, the operator had a critical opportunity to reconfigure the participants' practices, and not least reframing the element of meaning associated with mobility and electricity demand. Clever's establishment of new smart grid infrastructure and installation of private EV charging equipment were also legitimated and promoted in accordance with Government supported sustainable smart grid development.

Given Clever's role in the intervention, it seems very important to be aware of commercial interests in governing smart grid solutions. Critically, this commercial company operates in the interests of its five owners and energy companies (to protect the electricity grid from over-loads and to comply with energy-saving targets as required by the State) and it thus has no particular aim to decarbonise society. Clever's private commercial interests might therefore be seen to be in conflict with the aim of ensuring nation-wide decarbonisation, as their main interest is concerned with promoting EVs, and not with reducing driving. I argue how such 'greened' interventions – that operate within a capitalist mode of production and focus on commercial profit-making – therefore seem inconsistent with strategies of decarbonisation.

Andrew Sayer significantly acknowledges that capitalism can only be 'greened' if products become cheaper and they also become more environmental (Sayer, 2009). By acknowledging this, an SPT-based approach for wide-scale smart grid solutions and long-term sustainable transitions needs to be accommodated by multiple actors (that bring in many opportunities for intervention). Crucially, I argue that future decarbonisation and smart grid operations require the essential inclusion of public actors. As such, this enquiry proposes that future smart grid interventions need to involve a wider set of potential change agents. My case of a single EMO indicates that smart grid interventions need to be careful about entrusting private companies with the responsibility of decarbonisation, and suggests that their inclusion as the responsible co-actors in socio-technical change might also not be wise.

6.7.2 INEQUALITIES WITHIN SMART GRID TECHNOLOGIES

This research could have benefitted from paying more attention to the particular selection of participants, and hence reflected more on the differences between householders' degree of flexibility for integrating smart-grid technologies. By operationalising Southerton's concept of 'dispositions', analysis elucidated considerable differences in householders' flexibility to make changes to their everyday practices (cf. paper III). The household members' different dispositions and personal procedures influenced their commitment to and engagement with time shifting and EV-driving. Concepts such as trust, convenience and comfort would have been interesting to examine further, since such terms are associated with senses and feelings, and therefore are likely to vary greatly according to different social groups and cultures. The capacity and willingness for householders to reschedule their practices varied, and was partly dependent upon households' orientation towards meeting social norms, saving money, or saving time. While some households were motivated by economic incentives, others favoured saving time and prioritised the freedom to follow their own temporal schedules. This finding highlights the importance of designing demand-side management interventions that can accommodate householders' different dispositions.

Despite the participants differing in terms of household socio-economic parameters, both samples in this investigation shared several assets; like having a regular income, living in a house, owning a car (in advance of the trial), and having similar access to an electricity supply. In addition, some interviewees declared plans to install PVs, and expected that they would become 'prosumers'. Differences between householders' flexibility and temporal patterns of practice would likely have varied more with a greater spread in socio-economic variables, illustrating social groups' diverse access to energy (Walker, 2014). Given this, the participants in my investigation can be considered as 'special users', which Southerton and McMeekin associate with radical socio-technical innovations at the niche level. They therefore represent particular social relations that seem only to matter in sustainability transitions if they play some part in reconfiguring collective practices at a greater scale of socio-technical change (McMeekin & Southerton, 2012).

This observation underscores the importance of issues, such as inequality and justice, in relation to householders' integration of smart technologies. As Walker (2014) emphasises demand-response technologies can have potentially unequal consequences for energy consumers in terms of; pricing, utility, and capacity to free up established rhythms of energy-using practices. The impact on low-income households remains an open question. Further, Walker states that there is much scope for social science research to investigate the relations between time, practices and demand that can help inform policy initiatives that seek to rework the relationship between energy supply and demand (Walker, 2014).

6.7.3 GENDER ISSUES

Another issue of inequality, which continuingly featured in my empirical material and which deserves more attention, is the differing relationship of men and women to technology, as well as to participation in housekeeping activities. Based on findings from several studies, Corneliussen (2012) outlines how the

> "cultural association between masculinity and technology in Western societies is hard to exaggerate" (Corneliussen, 2012) and further argues that discursive constructions of gender and ICT reproduce the "gender gap in numbers, in activities and in discourses (…)" (ibid:3).

My empirical material clearly demonstrates huge differences between the interactions of men and women with respect to the EVs and to housekeeping chores, such as laundry and dish-washing. Given this, a report based on a time-use diary study higlights the significant gender differences related to the amount of time used on housekeeping activities, and to how housework activities and time pressures vary with the age of both children and parents (Bonke, 2002). Despite men in general participating more in housework and childcare activities, there are still considerably inequalities between men and women in these temporal commitments (Holter et al., 2009). In my interviews I also discovered gender differences in participants' experiences of 'meaningful' driving and 'timing'. Male interviewees stressed a particular interest in the technology – the technological attributes of the EVs, whereas female interviewees often underlined the pro-environmental attributes associated with driving electric. This finding seems very valuable for producers to gain further insight to. Further, female participants expressed a greater consciousness about environmental and climate-related issues. As such, in this area of gender equality, my inquiry supports the findings of many other studies.

6.7.4 SMART TECHNOLOGIES IN MATERIALITY AND TIME & SPACE

Aspects of materiality and automation also deserve increased attention. Given householders' experiences with time shifting their electricity-consuming practices, empirical observations point to an interesting interplay between practitioners' bodily involvements in practices and the delegation of specific activities (tasks) to machines (semi-automatisation), which is located in different spaces. These findings resulted in a paper written with Toke Haunstrup Christensen, and submitted to the DEMAND conference in Lancaster (March, 2016).

The paper demonstrates that not only the specific design of technologies, but also the general materiality and physical layout of the home, influence the extent to which households time shift their practices. This point to the importance of recognising how everyday household practices are temporally and spatially embedded and how time shifting particular practices can negatively interfere with the performance of other practices. These empirical findings call for theoretical reflections about the relationship between human and non-human actants, and how these interplays influence possible strategies for time shifting electricity demand. As part of this, the concept of 'distributed agency' (Sahakian & Wilhite, 2013; Strengers et al., 2014) within assemblages of practice could prove a useful concept for analysing households' flexibility to time shift their electricity consumption. These findings also reinforce Shove et al.'s (2015) recommendation about intervening in the infrastructural conduct of practices.

Considering external forces impacting EV adoption (cf. Paper II and Paper IV), this research has acknowledged the merit of further analysing temporal and spatial contexts. To accomplish EV adoption and release their smart grid potential, contextual analyses of time, space, and resources are important. The interdependence between this technology and its contexts, increase the value of undertaking comparative analysis. For example, comparative studies of EV adoption in Norway and Denmark, could illuminate matters of space, time, resource availability, and political incentives, and could provide new knowledge about potentially effective smart grid interventions.

6.7.5 CONTRIBUTIONS FROM TRANSDISCIPLINARY MOBILITY RESEARCH

SPT provides a significant framework for analysing how EVs are intergrated within households' everyday life, but it is recognised that particular interdisciplinary mobility research has the potential to contribute valuable insights as well (Sheller & Urry, 2006; Urry, 2004, 2007). Corresponding with my SPT-based approach, (particular) mobility research also rejects the idea of socio-technical changes in mobility systems as based on technological transformations, individual choices and economic forces (e.g. Freudendal-Pedersen & Cuzzocrea, 2015:4). Significantly, this research underlines the need to challenge the common understanding of ‘frictionless speed’ as enabling better and happier lives (Jensen and Freudendahl, 2012).

Future research will most likely ‘win’ by combining SPT with interdisciplinary mobility research in order to better understand how complex mobilities are (re)configured through households’ everyday lives (and *vice versa*). The addition of interdisciplinary mobility research would significantly illuminate how the proposed transition of current mobility practices largely relates to changing mobility cultures. This position reinforces the need to understand the role of shared meanings of mobility and movement in affecting EV adoption and use (Freudendal-Pedersen & Cuzzocrea, 2015). Conceptualising and reframing ‘meaning’ in this way, highlights the need for visions of the future that provide alternatives to failing neo-liberal attempts to encourage more sustainable mobility practices. Here, ‘utopian thinking’ provides a promising normative dimension of sociological thinking to reimagine resources and possibilities for sustainable development (Hviid Jacobsen & Tester, 2012).

6.7.6 COMMUNITY-BASED SMART GRID DEVELOPMENT

Related to the overall objective of this thesis, to expand understanding of the complexity associated with integrating smart grid technologies into householders’ daily lives, I have acknowledged the importance of exploring smart grid innovations that are initiated by civil society or grass roots organisations. However, my (pre-determined) analytical framework, was concerned with exploring the interaction between two particular smart grid strategies – ‘EV-testing’ and ‘time shifting’ – as implemented by a smart grid operator. In contrast, community-based initiatives could offer the most promising intervention approaches, because householder engagement and proactive involvement, are fundamental for developing comprehensive smart grid solutions (Christensen et al., 2016).

Smart grid initiatives produced by civil society and originating from the bottom-up community level, likely already work under ‘real-life’ conditions, and therefore may already indicate successful smart grid solutions for particular temporal and spatial contexts. As such, studies of community-based smart grid demonstration projects, designs, challenges, and solutions could enhance our understanding of how comprehensive solutions target final-consumers (Wolsink, 2012). Considering householders' crucial role as flexible demand-managers and 'prosumers' that can help to balance the grid, understanding householders' real-life experiences and recommendations is essential to ensure consumer adoption and acceptance strategies (Gangale et al., 2013). Thus, in-depth case-studies of smart-grid solutions that work in 'real-life' settings, would contribute to developing comprehensive solutions for future smart grid and energy system transitions.

7. CONCLUSIONS

The thesis investigates *how the smart grid solutions, electric vehicles and static time-of-use pricing, are integrated within households' everyday life?* Adopting a social practice theory (SPT) based conceptual and analytical approach, the thesis offers a useful framework for understanding the 'dynamics' of socio-technical change and the (re)production of social practices, when testing and integrating two smart grid technologies which are anticipated to be used in Denmark on everyday basis in the near future. Overall, the purpose of this research has been to gain knowledge about how to design comprehensive smart grid solutions that take into account the complex social factors that are associated with electricity consumption. The assumption is that the 'flexibility' associated with sustainable household practices, requires solutions that operate in 'smart' ways in real-life conditions.

The continuous interplay between qualitative empirical material and theoretical conceptualisations has led me to draw on different analytical frameworks as the research has proceeded. However, overall, my research process has been characterised by an on-going reflection between what I discovered in my empirical data and SPT conceptualisations and implications. In the following section, I first introduce key findings from the four individual papers comprising this thesis. Thereafter, I present the overall concluding points relevant to all papers and describe the major contributions of the thesis.

7.1 KEY FINDINGS FROM PAPERS

The *first* paper showed that the dominant vision of smart grid design and technology is dominated by an overarching 'supplier-driven' assumption that is based on accomplishing demand-side management through consumers' 'micro-operation' of the grid, and by balancing how consumers use, store and produce electricity depending on the overall energy system requirements. The review of research and development (R&D) in Denmark, demonstrated that the majority of Danish smart grid projects and activities can be divided into two different approaches. The first approach, which is dominant, focuses on purely technological solutions that are controlled by automated remote management of appliances by the electricity companies, and that include very little participation by consumers. Alternatively, the second approach assumes that grid flexibility will be provided through the active participation of consumers that are motivated by receipt of information and electricity prices (real-time pricing and static time-of-use pricing).

Whether 'smart flexible electricity consumption' is accommodated by passive or active consumer engagement, this paper highlights the risk that technological designs can sometimes lead to unintended side-effects that might serve to increase electricity consumption. Instead of continuing to implement such techno-rational approaches to electricity demand reduction, this paper suggests that interventions – including operators and other core actors – need to recognise and work with the configurations of collective practice performances, that result in invisible and inconspicuous electricity consumption throughout everyday life. Hence, this paper established the SPT-based theoretical orientation that underpinned the research process.

Employing a SPT-based approach, the *second* paper investigates the interplay between two smart grid projects – 'Test an EV' (TEV) and 'Dynamic Network Tariff' (DNT) – and householders' everyday practices. Based on qualitative interviews, this study explores how these interventions' attempted demand-side management changes the dynamics of (consumption) practices in everyday domestic life. The paper discusses how the combined trial intended to increase participants' flexibility to postponing usual domestic practices, by emphasising how time shifting has environmental benefits, and how the DNT could also deliver attractive economic savings by saving money on household electricity bills.

By examining the different elements configuring particular domestic practices, my analysis demonstrated how different links and interrelations between practice elements led to new driving performances being developed, and enabled householders to postpone the usual timings of dish-washing, laundry and EV-charging in order to capitalise on the low tariffs available at night. Rather than explaining this flexibility as the result of the economic incentives (like the operators), this paper emphasised the elements of 'institutionalised knowledge and explicit rules' and 'engagement' as fundamental in (re)shaping the participants' practices. New driving performances were characterised by test-drivers' increased awareness of the EV engines' levels of energy use, and the battery's capacity to store electricity, and this encouraged more environmental-friendly driving techniques. Although all households to some degree managed to time shift their domestic practices, the study revealed that the new time constraints were experienced as inconvenient and stressful. Furthermore the study significantly demonstrates how the smart grid technologies created some important unintended negative side effects.

The *third* paper examines the complex relationship between temporalities and practices, and seeks to understand the anticipated potential of time shifting electricity-consuming activities that make-up householders' everyday lives. Acknowledging the recursive relationship between practices and temporalities (Southerton, 2012), this paper explores how time shifting dish-washing, laundry and EV-charging practices is influenced by householders' existing practice rhythms and temporalities. The analysis shows that time shifting generated some new 'coupling constraints' (Hägerstrand, 1985) such as, loading and unloading the washing and dishwashing machines in the mornings, which challenged householders' control of the temporal organisation of their daily activities (Shove, 2003:170).

In fact, the smart grid technologies decreased temporal flexibilities in householders' everyday lives. Following Southerton's concept of 'hot spots' and 'cold spots' (Southerton, 2003, 2012), newly adopted practices of hanging clothes up during tightly scheduled mornings ('hot spots'), challenged time dedicated to cherished activities, like being together around the breakfast table ('cold-spots'). Thus, the impact of uncontrollable elements proved to be one of the main challenges to be negotiated in order to integrate smart grid solutions into householders' everyday lives.

The paper recommends that future smart grid interventions are convenient, reliable, predictable, and not overly time-demanding. Further we emphasise how synchronisation between practices, relations between time and space, and householders' personal 'dispositions' have a large influence on householders' flexibility to time shift. Considering all practices as 'nexus[es] of sayings and doings' (Schatzki, 1996), this paper compares householders' 'sayings' about time shifting with their 'doings', as analysed from load profiles. The results confirm householders' 'sayings' as they verify that a new (temporally shifted) peak electricity demand formed amongst households participating in both the DNT and TEV trials. This finding indicates that future demand-management strategies could benefit from interventions being combined.

The *fourth* paper is based on the initial observation made about the disconnection between consistently (s)low EV-uptake and non-adoption, and claims that EVs are able to meet test-drivers' complete driving needs. In line with several demonstration projects, results from the data-loggers (extracted by DTU-Transport) concluded that the tested EVs covered 98.9% of the participants' driving needs (Clever's final report, 2014). This investigation found participants' perspectives to differ completely from this appraisal. None of the participants wanted to adopt an EV following the trial, due largely to the tested engines being incompatible with their everyday lives because of their limited driving range, decreased comfort and security, and high purchase price (compared to conventional cars).

This paper recognised the need to go beyond existing assumptions of EV adoption. The first part of the analysis discusses the mobility operators' strategy to increase EV adoption. Based on Spurling and McMeekin's (2014) conceptualisation of three cross-cutting practice dynamics that can inform interventions in mobility patterns, this analysis demonstrates how the TEV intervention, to some extent, tried to 'recraft' and 'substitute' conventional driving practices, but failed to consider 'how practices interlock'. This latter dynamic is acknowledged to be pivotal for sustainable transitions.

Based on the empirical results from focus group interviews with winter testpilots, the second part of the analysis recommends that smart mobility interventions need to recognise the systems of practice shaping current (auto)mobility (Watson, 2012). I also acknowledge the need to understand the path-dependency of practice intersections in order to change the level, scale, and character of current demand. In line with recent research (Shove et al., 2015; Shove & Walker, 2014; Spurling & McMeekin, 2014), this paper acknowledges the need for new configurations of 'normality' and for bringing 'negotiability of demand' to the political agenda. Moreover, this paper calls for further conceptualisations of whom, where, when and how to govern the current resource-intensive systemic practices.

7.2 OVERALL KEY OUTCOMES

Based on the key findings from the papers, I want to highlight the following key outcomes that address the research questions of this thesis. Although the research questions are tightly interconnected and linked, the following concluding points seek to answer the four research questions one by one.

1. What characterises mainstream assumptions informing the integration of households within the smart grid?

Despite growing recognition of the 'social' dimensions of 'smart', the techno-rational regime still dominates implementation of smart-grid technologies within households. The comprehensive review of EV adoption illustrates the mainstream one-dimensional techno-rational approaches used in academia and policy to spread this potential smart grid technology (for example, through technological innovation and economic incentives). It is anticipated that demand-side management will be accomplished without needing to understand the fundamental temporal and spatial settings of people's social practices. For example, the case study of electric mobility operator’s provision of EVs and testing of householders’ flexibility to time shift places emphasis on the role of prices and information as core drivers in changing householders’ everyday consumption patterns. Considering the crucial dependence of smart-grid technologies on consumers being willing and flexible enough to integrate them into their daily routines and habits, minimal recognition of this requirement in most smart-grid interventions represents an oversight.

2. What characterises the electric mobility operator’s intervention in households’ social practices?

Examining households participating in the combined smart grid trial, testing both EVs and time-of-use pricing, the enquiry shows how householders’ successfully time shifted EV-charging, laundry and dish-washing activities to lower electricity demand periods (that were cheaper). This result could support the operator’s anticipation that ‘economic incentives’ and ‘information’ would act as successful socio-technical change instruments. Instead, this investigation emphasises ‘commitment’ and ‘engagement’ to follow the operators’ ‘rules’ as crucial ‘drivers’, whereas economic incentives were found to have had a minor impact on householders modifying existing and developing new practices. This finding crucially illustrates how ensuring positive ‘meaning’ related to ‘engagement’ and ‘participation’ is crucial to encourage and achieve required time shifting at the domestic level.

Despite the smart-grid intervention to some extent acknowledging the value of users’ performances, experiments and experiences in practice, the operator still constructed the ‘meaning’ of mobility in relation to the current (unsustainable) automobility system. The operator promoted EVs as a substitute to conventional driving, by highlighting EVs’ ability to cover daily driving needs and emphasising the engine’s lower operational costs over five years when compared with petrol cars. Considering the operator’s promotion and the general ‘hype’ around EVs worldwide, paradoxically none of the participants wanted to adopt an EV after the three-month test-period. The operator anticipates that the sale of charging equipment will expand once EV technologies are perfected, regulations around EV-technology are fixed, and electricity taxes are reformed. Hence, this case of mobility intervention constructs a picture of householders as individual rational decision-making ‘micro-operators’ that will only respond favourably by purchasing/leasing an EV when conditions are ‘right’.

The enquiry demonstrates how the integration of the tested ‘smart’ technologies influenced households’ everyday life. In particular, limitations associated with the first generation of mass-produced EVs, and deficiencies in the smart-grid technology were recognised as important in shaping the performances of households' everyday practices. In particular, the group of winter testpilots experienced the EVs as far too uncomfortable, inconvenient, insecure and expensive for their future investment. This finding challenges current 'hype' about EVs as moving beyond the pilot and demonstration phase. Furthermore, the householders' experiences of empty batteries in the morning, due to bugs in the charging system remote control, were experienced as extremely stressful and problematic. Deficiencies experienced in the remote control, made the operator's conclusion about households' having a clear preference for automatic load-management (controlled by Clever), a little misleading.

Overall, these uncontrollable and unpredictable aspects of current smart-grid technologies form key reference points around which comprehensive smart-grid solutions can be designed and implemented. This study of a smart grid operator's intervention in householders' everyday life, emphasises that (even when the technology is functioning as intended) householders' habits and routines are complex and interlinked, and how these interlinkages are essential to understand in order to increase domestic 'flexibility' in energy-consuming activities and to release the peak-shaving potential.

3. How does a social practice-based analytical approach provide essential alternative knowledge for integrating smart grid technologies within householders' everyday lives?

When I zoom out and look at the thesis as a whole, there are five social practice theory based aspects that have continually influenced my analytical approach. First, SPT significantly increased my awareness of the essential interrelation between materialities and social life. Second, acknowledging social practices as situated in time and space has been essential. Third, recognising the interrelations and links between practices has developed fundamental analytical insights. Fourth, the reproduction and path dependency of particular practices, and their ability to influence broader socio-technical 'structures', has reinforced my argument that there is a distinct need to attempt to 'govern' (systemic) practices. Finally, this conceptual approach strengthened my ontological and methodological awareness of the importance of understanding householder 'doings', which both influenced the empirical design of the thesis, and 'what I discovered' in the field.

Qualitative interviews and in-depth studies elucidated the normalised invisible habits and routines performed in householders' 'social worlds'. First and foremost the SPT-based framework clarified the (new) links and interrelations between different elements intended to reconfigure driving performances and time shift practices. Moreover, the 'temporality of practices' was emphasised as pivotal for understanding householders' flexibility in accommodating change. Going beyond participants' new consumption patterns, I explained how time shifting was influenced by the existing synchronisations and interrelations between social practices, which decreased participants' 'flexibility' to change. This demonstrates how social practices are interrelated and depend on wider systems of practice that determine collective and institutional rhythms and inform the temporalities of a wide-range of everyday practices. In particular, this enquiry reveals how time constraints related to emptying the dishwasher and hanging-up laundry were challenged by existing routines and habits in the mornings, which in turn were shaped by overlapping systemic practices (e.g. work and education).

This enquiry suggests that smart-grid solutions need to be aware of time-consuming obligations, avoid disturbing households' (increasingly sacrificed) 'cold-spots' of social 'togetherness', and not least attempt to bundle new activities together with existing routines. Meaningful activities, such as 'breakfasting together', tend to be prioritised over other practices, producing a kind of 'hierarchy' in households' performance of practices. Therefore the design of interventions should consider coupling practices (such as load-management and 'close-the-house-down-before-going-to-sleep' practices), to make it easier for households to time shift their daily practices. This indicates how smart-grid strategies could benefit from acknowledging the complexity associated with changing social practices, instead of focusing on attempts to modify single activities. Further, individual interviews illustrated a huge variation amongst householders' 'flexibility', which indicates that smart technologies are integrated differently according to householders' varying dispositions. Consequently, this research recommends that future smart-grid interventions take householders' different dispositions into account and explore how to activate the practices of smart-grid 'prosumers'.

Critically, the case study revealed several unintended negative side-effects of integrating smart grid technologies. Most striking was that the winter test-drivers (without pricing schemes) plugged-in their EVs when they came home from work, and thus charging coincided with the critical evening electricity demand peak between 17:00-19:00. Further this group of participants begun to use electric heaters to warm-up the EV engines on cold winter mornings. Among the participants in the test-trial, time shifting also led to more frequent clothes-washing, which could prompt increased investments in tumble dryers. In addition, almost all test-drivers described that having an extra car at their disposal increased their experiences of comfort and convenience, and highlighted (a previously unrecognised) need for a second household car in the future. Finally, participants stressed that the EVs increased the amount of driving trips made during the test-period, as EV-driving replaced bicycle rides and walking.

These significant examples of exacerbations in electricity demand related to integrating smart technologies, underpin the above conclusion that interventions, despite their pro-environmental strategies and eco-friendly products, frequently fail to take the dynamics of changing household practices into account. This demonstrates how dominant techno-rational approaches can serve to justify electricity-demanding expectations by increasing levels of household comfort and convenience. Technologies only become ‘smart’ when they deliver comfort and pleasure, practices incorporating those technologies become meaningful to perform, and when they are successfully adopted into the temporal and spatial dynamics of daily domestic life. This illustrates how technological design needs to be user-friendly, and how interventions need to take into account how social practices are embedded in powerful ‘normalisation’ processes (relating to what make sense and what works under real-life conditions). This further underpins the need for a closer link between operators, producers and consumers to achieve a common notion for ‘the ‘meaning of smart’. Neglecting consumers’ habits and routines only increases the risk of developing useless and unsustainable smart-grid technology designs.

By demonstrating how habits and routines in our modern lives are interwoven in socio-material systems of energy consumption, this thesis suggests that smart grid operators, and other key actors, need to recognise how configurations of collective daily practice performances result in invisible and inconspicuous electricity consumption. Focusing on the collective practice performance aspects, and framing the householder as a carrier of practices rather than an individual deciding what to do, is crucial to help balance the socio-technical energy system.

4. How can social practices be governed for sustainability?

With regard to the worldwide ‘hype’ around EVs smart grid potential, and the operator’s promotion of EVs ability to meet householders’ everyday mobility needs, paradoxically none of the participants wanted to adopt an EV after the three-month test period. I suggest that these low-adoption rates are a result of Denmark’s car dependent infrastructure and current systems of automobility. The main explanation of the (s)low adoption is that the test-drivers expected the engines to substitute their combustion cars in terms of driving distance and comfort. Householder experiences of the engine’s limited range, flexibility, and freedom are determined by the assumption that cars can ‘normally’ fulfil a variety of different activities and duties in daily life. Automobility is an example of a deeply complex and profoundly embedded socio-technical practice, which requires going beyond technological change to reduce fossil fuels by the scale necessary. Employing a ‘systems of practice’ approach suggests that smart-grid interventions affect the interlocking of the practices in which automobility practices are enmeshed. Thus, analysis needs to go further than understanding how EV-driving and conventional driving practices are changed and reproduced, and instead recognise the multiple systemic practices of which driving are a part.

Instead of reproducing traditional interventions by focusing on one-dimensional technology fixes and changing people’s pro-environmental behaviours through information, education and incentives, this analysis emphasises how reducing fossil fuels to the scale required, needs interventions that seek to change how the current systems of resource-intensive practices are interlocked. Changing current energy and transport systems require interventions to acknowledge the path dependency of the present infrastructural systems of (mobility) practices, and to recognise the synchronisation of mobility with other practices such as; working, grocery-shopping, and leisure. A precondition for radical socio-technical change is therefore that current institutions and their social practices are interrogated. Essentially such ambitious interventions bring the ‘negotiability of demand’ onto the political agenda. Thus key governing actors need to discuss what demand is for, and how to change the normalisation of electricity and mobility demand.

This analysis opens up discussions about how, who, and where to govern and intervene in the current resource-intensive automobility system. This thesis raises concerns about the current ‘hype’ that EVs have the potential to deliver sustainable socio-technical change, since mass EV-adoption would likely increase the amount of vehicles in our cities and regions. Instead of substituting combustion cars, a possible unsustainable scenario could be that EVs become a supplementary household car. Given this concern, key actors, such as policy makers, network operators, system builders and other relevant stakeholders on the ‘system side’, should promote smart-grid design that includes less-resource intensive practices. They should also develop ‘meaningful’ smart designs for households that can synchronise with the production of renewables in the grid.

Finally, a wider set of potential change agents and key actors should make long-term sustainable policies, which are ambitious enough to negotiate current concepts of electricity demand. Based on experiences developed throughout this investigation, I recommend the development of governance incentives, that are based on an ambitious discussion of the quality of life, that are able to negotiate and reconstruct current understandings of materiality, and that can change the existing ‘normalisation’ of meaningful (but often unsustainable) everyday practices. Instead of reproducing the dominant techno-rational ‘smart’, a reformulation of ‘smart’ must be based on in-depth understandings of innovative technological designs that work under real-life conditions. At the same time, understandings of ‘quality of life’ must be challenged to incorporate ‘meaningful’ less resource-intensive consumption practices.

8. REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), pp.179-211. http://doi.org/10.1016/0749-5978(91)90020-T.

Al-Alawi, B. M., & Bradley, T. H. (2013). Review of hybrid, plug-in hybrid, and electric vehicle market modeling Studies. *Renewable and Sustainable Energy Reviews*, *21*, pp. 190-203. http://doi.org/10.1016/j.rser.2012.12.048.

Augenstein, K. (2015). Analysing the potential for sustainable e-mobility – The case of Germany. *Environmental Innovation and Societal Transitions, 14*, pp. 101-115. http://doi.org/10.1016/j.eist.2014.05.002.

Axsen, J., Mountain, D. C., & Jaccard, M. (2009). Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. *Resource and Energy Economics*, *31*(3), pp. 221-238. http://doi.org/10.1016/j.reseneeco.2009.02.001.

Bakker, S., & Farla, J. (2015). Electrification of the car – Will the momentum last?: Introduction to the special issue. *Environmental Innovation and Societal Transitions*, *14*, pp. 1-4. http://doi.org/10.1016/j.eist.2014.07.002.

Bakker, S., & Jacob Trip, J. (2013). Policy options to support the adoption of electric vehicles in the urban environment. *Transportation Research Part D: Transport and Environment*, *25*, pp. 18-23. http://doi.org/10.1016/j.trd.2013.07.005.

Bakker, S., Maat, K., & van Wee, B. (2014). Stakeholders interests, expectations, and strategies regarding the development and implementation of electric vehicles: The case of the Netherlands. *Transportation Research Part A: Policy and Practice*, *66*, pp. 52-64. http://doi.org/10.1016/j.tra.2014.04.018.

Barr, S. (2006). Environmental action in the home: Investigating the 'value-action' gap. *Geographical Association*, pp. 43-54.

Bonke, J. (2002). *Tid og Velfærd*. Copenhagen: The Danish National Centre for Social Research.

Bourdieu, P. (1990). *The Logic of Practice*. Stanford University Press.

Bradley, T. H., & Frank, A. A. (2009). Design, demonstrations and sustainability impact assessments for plug-in hybrid electric vehicles. *Renewable and Sustainable Energy Reviews*, *13*(1), pp. 115-128. http://doi.org/10.1016/j.rser.2007.05.003.

Brown, S., Pyke, D., & Steenhof, P. (2010). Electric vehicles: The role and importance of standards in an emerging market. *Energy Policy*, *38*(7), pp. 3797-3806. http://doi.org/10.1016/j.enpol.2010.02.059.

Budde, B., Alkemade, F., & Hekkert, M. (2015). On the relation between communication and innovation activities: A comparison of hybrid electric and fuel cell vehicles. *Environmental Innovation and Societal Transitions*, *14*, pp. 45-59. http://doi.org/10.1016/j.eist.2013.11.003.

Burgess, J., Bedford, T., Hobson, K., Davies, G., & Harrison, C. (2003). (Un)sustainable consumption. In F. Berkhout, M. Leach, & I. Scoones (Eds.), *Negotiating Environmental Change: New Perspectives from Social Science*. Cheltenham UK: Edward Elgar.

Butler, J. (1990). *Gender Trouble: Feminism and the subversion of identity*. New York: Routledge.

Callon, M. (1986). The Sociology of an Actor-Network: The Case of the Electric Vehicle. In M. Callon, J. Law, & A. Rip (Eds.), *Mapping The Dynamics Of Science And Technology*. pp. 19-35. London: The Macmillan Press Ltd.

Callon, M. (2012). Society in the making: The study of technology as a tool for sociological analysis. In W. E. Bijker, T. P. Hughes, & T. Pinch (Eds.), *The Social Construction of Technological Systems - New Directions in the Sociology and History of Technology*. (Aniversary Edition). London: The MIT Press, Cambridge, Massachusetts London, England.

Caperello, N. D., & Kurani, K. S. (2012). Households' Stories of Their Encounters With a Plug-In Hybrid Electric Vehicle. *Environment and Behavior*, *44*(4), pp. 493-508. http://doi.org/10.1177/0013916511402057.

Christensen, T. H., Ascarza, A., & Throndsen, W. (2013a). *Country-specific factors for the development of household smart grid solutions: Comparison of the electricity systems, energy policies and smart grid R&D and demonstration projects in Spain, Norway and Denmark*. SBI forlag.

Christensen, T. H., Ascarza, A., Throndsen, W., Gram-Hanssen, K., & Friis, F. (2013b). The role of households in the smart grid: A comparative study. *Eceee 2013 Summer Study on Energy Efficiency*.

Christensen, T. H., Friis, F., Ryghaug, M., Skjølsvold, T. M., Throndsen, W., Fernandez, S. R., & Perez, E. S. (2016). *IHSMAG WP5: Recommendations and criteria for the design of smart grid solutions for households - Lessons learned for designers and policy makers from the IHSMAG project*. Copenhagen: Danish Building Research Institute.

Christensen, T. H., Gram-Hanssen, K., & Friis, F. (Eds.). (2013c). Households in the smart grid: existing knowledge and new approaches, in Hansson, L., Holmberg, U. & Brembeck, H. (red.) *Making sense of consumption: Selections from the 2nd Nordic Conference on Consumer Research 2012*. Göteborg: Centre for Consumer Science, University Gothenburg. Kap. 20, pp. 333-348.

Christensen, T. H., & Røpke, I. (2005). Can practice theory inspire studies on ICTs in everyday life? *Paper for the 7th Conference of the European Sociological Association, Torun, Poland*.

Clarke, A. E. (2005). *Situational analysis: Grounded theory after the postmodern turn*. University of California: Sage Publications.

Clever's refunding application. (2011). pp. 1-49. Copenhagen.

Clever’s final report. (2014). pp. 1-142. Copenhagen.

Coffey, A. J., & Atkinson, P. A. (1996). *Making Sense of Qualitative Data Analysis: Complementary Strategies.* Sage Publications.

Copenhagen Municipality. (2011). *Copenhagen’s Cycling Strategy 2011-2025*. Copenhagen.

Copenhagen Municipality. (2012). *Action Plan for Green Mobility* (pp. 1-84). Copenhagen.

Corneliussen, H. G. (2012). *Gender-Technology Relations: Exploring Stability and Change*. London: Palgrave Macmillan.

Cowan, R., & Hultén, S. (1996). Escaping lock-in: The case of the electric vehicle. *Technological Forecasting and Social Change*, *53*(1), pp. 61-79. http://doi.org/10.1016/0040-1625(96)00059-5.

Danish Electric Vehicle Alliance. (2013). *Dansk elbilalliance: 10 punkterede myter om elbiler 2013*. Danish Energy Association.

Danish Government. (2011). *Energy Strategy 2015 - from coal, oil and gas to green energy*. pp.1-66. The Danish Government.

Danish Government. (2013a). *Smart Grid Strategy: The intelligent energy system of the future*. pp.1-23. Danish Ministry of Climate, Energy and Building.

Danish Government. (2013b). *The Danish Climate Policy Plan: Towards a low carbon society*. pp. 1-64. The Danish Government.

Danish Transport Authority. (2012). *Minute on Electric Vehicles*. pp.1-7. Danish Transport Authority.

Darby, S. J., & McKenna, E. (2012). Social implications of residential demand response in cool temperate climates. *Energy Policy*, *49*, pp. 759-769. http://doi.org/10.1016/j.enpol.2012.07.026.

Daziano, R. A., & Chiew, E. (2012). Electric vehicles rising from the dead: Data needs for forecasting consumer response toward sustainable energy sources in personal transportation. *Energy Policy*, *51*, pp. 876-894. http://doi.org/10.1016/j.enpol.2012.09.040.

Deleuze, G., & Guattari, F. (1986). *Kafka: Toward a Minor Literature*. Minneapolis: University of Minnesota Press.

Diamond, D. (2009). The impact of government incentives for hybrid-electric vehicles: Evidence from US states. *Energy Policy*, *37*(3), pp. 972-983. http://doi.org/10.1016/j.enpol.2008.09.094.

Dijk, M., Orsato, R. J., & Kemp, R. (2013). The emergence of an electric mobility trajectory. *Energy Policy*, *52*, pp. 135-145. http://doi.org/10.1016/j.enpol.2012.04.024.

Druitt, J., & Früh, W.-G. (2012). Simulation of demand management and grid balancing with electric vehicles. *Journal of Power Sources*, *216*, pp. 104-116. http://doi.org/10.1016/j.jpowsour.2012.05.033.

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, *48*, pp. 717-729. http://doi.org/10.1016/j.enpol.2012.06.009.

Egmose, J. (2015). *Action Research for Sustainability. Social Imagination Between Citizens ans Scientists*. Ashgate.

Danish Energy Agency (2014). Screening af internationale policy-erfaringer vedr. grøn omstilling af transportsektoren. Energistyrelsen.

Eppstein, M. J., Grover, D. K., Marshall, J. S., & Rizzo, D. M. (2011). An agent-based model to study market penetration of plug-in hybrid electric vehicles. *Energy Policy*, *39*(6), pp. 3789-3802. http://doi.org/10.1016/j.enpol.2011.04.007.

European Commission. (2014). *Strategic Energy Technology (SET) Plan - Towards an Integrated Roadmap: Research & Innovation Challenges and Needs of the EU Energy System* (pp. 1-54).

European Commission JRS. (2013). JRS News Release: A look at the EU's research on electric cars. European Commission.

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, *12*(2), pp. 219-245. http://doi.org/10.1177/1077800405284363.

Fontaras, G., & Samaras, Z. (2010). On the way to 130 g CO2/km - Estimating the future characteristics of the average European passenger car. *Energy Policy*, *38*(4), 1826–1833. http://doi.org/10.1016/j.enpol.2009.11.059.

Foucault, M. (1978). *The History of Sexuality*. New York: Pantheon Books.

Franke, T., & Krems, J. F. (2013). What drives range preferences in electric vehicle users? *Transport Policy*, *30*, pp. 56-62. http://doi.org/10.1016/j.tranpol.2013.07.005.

Freudendal-Pedersen, M. (2007). *Mellem frihed of ufrihed - strukturelle fortællinger om mobilitet i hverdagslivet* (PhD-afhandling). Roskilde Universitetscenter: Institut for Miljø, Samfund og Rumlig Forandring.

Freudendal-Pedersen, M., & Cuzzocrea, V. (2015). Cities and Mobilities. *City & Society*, *27*(1), pp. 4-8.

Friis, F., & Gram-Hanssen, K. (2013). Integration of Smart Grid Technologies in Households: How Electric Vehicles and Dynamic Pricing change Social Practices in the Everyday Life? *Proceedings of ECEEE 2013 Summer Study 2013. Lindström, T. L. (Red.). E. pp. 1019-1030.*

Gadamer, H.-G. (1989). *Truth and Method* (2nd edition). London: Sheed and Ward.

Galus, M. D., Zima, M., & Andersson, G. (2010). On integration of plug-in hybrid electric vehicles into existing power system structures. *Energy Policy*, *38*(11), pp. 6736–6745. http://doi.org/10.1016/j.enpol.2010.06.043.

Gangale, F., Mengolini, A., & Onyeji, I. (2013). Consumer engagement: An insight from smart grid projects in Europe. *Energy Policy*, *60*, pp. 621-628. http://doi.org/10.1016/j.enpol.2013.05.031.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, *31*(8–9), pp. 1257-1274. http://doi.org/10.1016/S0048-7333(02)00062-8.

Geels, F. W. (2005). The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles (1860-1930). *Technology Analysis & Strategic Management*, *17*(4), pp. 445-476.

Geels, F. W. (2010). Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, *39*(4), pp. 495-510. http://doi.org/10.1016/j.respol.2010.01.022.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), pp. 24-40. http://doi.org/10.1016/j.eist.2011.02.002.

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*(3), pp. 399-417. http://doi.org/10.1016/j.respol.2007.01.003.

Giddens, A. (1984). *The Constitution of Society: Outline of the Theory of Structuration*. Cambridge: Polity Press.

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., & Stannard, J. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice*, *46*(1), pp.140-153. http://doi.org/10.1016/j.tra.2011.09.008.

Gram-Hanssen, K. (2011). Understanding change and continuity in residential energy consumption. *Journal of Consumer Culture*, *11*(1), pp. 61-78. http://doi.org/10.1177/1469540510391725.

Green II, R. C., Wang, L., & Alam, M. (2011). The impact of plug-in hybrid electric vehicles on distribution networks: A review and outlook. *Renewable and Sustainable Energy Reviews*, *15*(1), pp. 544-553. http://doi.org/10.1016/j.rser.2010.08.015.

Grønn Bil Prosjektrapport. (2013).

Hägerstrand, T. (1985). *Time-Geography: Focus on the Corporeality of Man, Society, and Environment. The Science and Praxis of Complexity*. Tokyo: The United Nations University.

Haley, B. (2015). Low-carbon innovation from a hydroelectric base: The case of electric vehicles in Québec. *Environmental Innovation and Societal Transitions*, *14*, pp. 5-25. http://doi.org/10.1016/j.eist.2014.05.003

Halkier, B. (2002). *Fokusgrupper* (1. udgave). Samfundslitteratur & Roskilde Universitetsforlag.

Halkier, B. (2003). The Challenge of Qualitative Generalizations in Communication Research. *Nordicom Information*, *24*(1), pp. 115-124.

Halkier, B. (2010). Focus groups as social enactments: integrating interaction and content in the analysis of focus group data. *Qualitative Research*, *10*(1), pp. 71-89. http://doi.org/10.1177/1468794109348683.

Halkier, B., & Jensen, I. (2008). Det sociale som performativitet - et praksisteoretisk perspektiv på analyse og metode. *Dansk Sociologi*, *19*(3), pp. 49-68.

Hargreaves, N., Chilvers, J., & Hargreaves, T. (2015). " What's the meaning of'smart'? A study of smart grids": Sociotechnical Report.

Hargreaves, T., Longhurst, N., & Seyfang, G. (2013). Up, down, round and round: connecting regimes and practices in innovation for sustainability. *Environment and Planning A*, *45*(2), pp. 402-420. http://doi.org/10.1068/a45124.

Hargreaves, T., Nye, M., & Burgess, J. (2010). Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. *Energy Policy*, *38*(10), pp. 6111-6119. http://doi.org/10.1016/j.enpol.2010.05.068

Hitchings, R. (2012). People can talk about their practices. *Royal Geographical Society*, *44*(1), 61–67. http://doi.org/10.1111/j.1475-4762.2011.01060.x

Højbjerg, H. (2004). Hermeneutik. In L. Fuglsang & B. Olsen (Eds.), *Videnskabsteori i samfundsvidenskaberne*. Roskilde Universitetsforlag.

Holter, Ø. G., Svare, H., & Egeland, C. (2009). Gender Equality and Quality of Life: A Norwegian Perspective. *The Nordic Gender Institute (NIKK)*, pp. 1-272.

Huijts, N. M. A., Molin, E. J. E., & Steg, L. (2012). Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renewable and Sustainable Energy Reviews*, *16*(1), pp. 525-531. http://doi.org/10.1016/j.rser.2011.08.018.

Hviid Jacobsen, M., & Tester, K. (2012). *Utopia: Social Theory and the Future*. Routledge.

Ingeborgrud, L. H. (2014). *Ren elektrisk kjøreglede - Elbilen i komfortkulturen* (Masteropgave i Studier av Kunnskap, Teknologi). NTNU Trondheim: Institutt for tverrfaglige kulturstudier Senter for teknologi og samfunn.

Jensen, A. F., Cherchi, E., & Mabit, S. L. (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle.

Transportation Research Part D: Transport and Environment, *25*, pp. 24-32. http://doi.org/10.1016/j.trd.2013.07.006.

Joint Research Centre: Smart Grid Projects Outlook 2014. (2014). Luxembourg: Publications Office of the European Union.

Kawgan-Kagan, I., & Daubitz, S. (2014). BEVs beyond Range Anxiety – Cognitive Interviews to Elicit the Perception of Mode Choice1. *Transportation Research Procedia*, *4*, pp. 387-390. http://doi.org/10.1016/j.trpro.2014.11.029.

Khan, M., & Kockelman, K. M. (2012). Predicting the market potential of plug-in electric vehicles using multiday GPS data. *Energy Policy*, *46*, pp. 225-233. http://doi.org/10.1016/j.enpol.2012.03.055.

Krupa, J. S., Rizzo, D. M., Eppstein, M. J., Brad Lanute, D., Gaalema, D. E., Lakkaraju, K., & Warrender, C. E. (2014). Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A: Policy and Practice*, *64*, pp. 14–31. http://doi.org/10.1016/j.tra.2014.02.019.

Kvale, S. (1996). *InterViews: An Introduction to Qualitative Research Interviewing*. Sage Publication Inc, London.

Lane, B., & Potter, S. (2007). The adoption of cleaner vehicles in the UK: exploring the consumer attitude–action gap. *Journal of Cleaner Production*, *15*(11-12), pp. 1085-1092. http://doi.org/10.1016/j.jclepro.2006.05.026.

Latour, B. (1993). We Have Never Been Modern - Bruno Latour | Harvard University Press.

Latour, B. (2005). *Reassembling the social: an introduction to actor-network-theory*. Oxford ; New York: Oxford University Press.

Lemoine, D. M., Kammen, D. M., & Farrell, A. E. (2008). An innovation and policy agenda for commercially competitive plug-in hybrid electric vehicles. *Environmental Research Letters*, *3*(1), 14003. http://doi.org/10.1088/1748-9326/3/1/014003.

Martin, E., Shaheen, S. A., Lipman, T. E., & Lidicker, J. R. (2009). Behavioral response to hydrogen fuel cell vehicles and refueling: Results of California drive clinics. *International Journal of Hydrogen Energy*, *34*(20), pp. 8670-8680. http://doi.org/10.1016/j.ijhydene.2009.07.098.

Mau, P., Eyzaguirre, J., Jaccard, M., Collins-Dodd, C., & Tiedemann, K. (2008). The “neighbor effect”: Simulating dynamics in consumer preferences for new vehicle technologies. *Ecological Economics*, *68*(1–2), pp. 504-516. http://doi.org/10.1016/j.ecolecon.2008.05.007.

Mazur, C., Contestabile, M., Offer, G. J., & Brandon, N. P. (2015). Assessing and comparing German and UK transition policies for electric mobility. *Environmental Innovation and Societal Transitions*, *14*, pp. 84-100. http://doi.org/10.1016/j.eist.2014.04.005.

McKinsey&Company. (2014). *Evolution: Electric vehicle in Europe: gearing up for a new phase*. pp. 1-60. Amsterdam Roundtable Foundation.

McMeekin, A., & Southerton, D. (2012). Sustainability transitions and final consumption: practices and socio-technical systems. *Routledge*, *Vol. 24*(No. 4), pp. 345-361.

Moons, I., & De Pelsmacker, P. (2012). Emotions as determinants of electric car usage intention. *Journal of Marketing Management*, *28*(3-4), 195-237. http://doi.org/10.1080/0267257X.2012.659007.

Morgan, D. L. (1997). *Focus Groups as Qualitative Research*. DAGE Publications.

Nicholls, L., & Strengers, Y. (2015). Peak demand and the “family peak” period in Australia: Understanding practice (in)flexibility in households with children. *Energy Research & Social Science*, *9*, pp. 116-124. http://doi.org/10.1016/j.erss.2015.08.018.

Nicolini, D. (2009). Zooming In and Out: Studying Practices by Switching Theoretical Lenses and Trailing Connections. *Organization Studies, 30*(12), pp. 1391-1418. http://doi.org/10.1177/0170840609349875.

Norwegian Ministry. (2012). *Norwegian Climate Policy: Report No. 21 (2011-2012) to the Storing (white paper) Summary*.

Nyborg, S., & Røpke, I. (2011). Energy impacts of the smart home - conflicting visions. *ECEEE 2011 Summer Study Proceedings: Energy Efficiency First: The Foundation of a Low-Carbon Society*, *4*, pp. 1849-1860.

Nykvist, B., & Nilsson, M. (2015). The EV paradox – A multilevel study of why Stockholm is not a leader in electric vehicles. *Environmental Innovation and Societal Transitions*, *14*, pp. 26-44. http://doi.org/10.1016/j.eist.2014.06.003.

Ozaki, R., & Sevastyanova, K. (2011). Going hybrid: An analysis of consumer purchase motivations. *Energy Policy*, *39*(5), pp. 2217-2227. http://doi.org/10.1016/j.enpol.2010.04.024.

Peters, A., & Dütschke, E. (2014). How do Consumers Perceive Electric Vehicles? A Comparison of German Consumer Groups. *Journal of Environmental Policy & Planning*, *16*(3), pp. 359-377. http://doi.org/10.1080/1523908X.2013.879037.

Powells, G., Bulkeley, H., Bell, S., & Judson, E. (2014). Peak electricity demand and the flexibility of everyday life. *Geoforum*, *55*, pp. 43-52. http://doi.org/10.1016/j.geoforum.2014.04.014.

Ramsbrock, J., Vilimek, R., & Weber, J. (2013). Exploring electric driving pleasure–the BMW EV pilot projects. In *Human-Computer Interaction. Applications and Services.* pp. 621-630. Springer.

Reckwitz, A. (2002). Toward a Theory of Social Practices: A Development in Culturalist Theorizing. *European Journal of Social Theory*, *5*(2), pp. 243-263. http://doi.org/10.1177/13684310222225432

Registration Tax Law. (2014). Bekendtgørelse af lov om registreringsafgift af motorkøretøjer m.v. (registreringsafgiftsloven).

Rezvani, Z., Jansson, J., & Bodin, J. (2015). Advances in consumer electric vehicle adoption research: A review and research agenda. *Transportation Research Part D: Transport and Environment*, *34*, pp. 122-136. http://doi.org/10.1016/j.trd.2014.10.010

Richardson, D. B. (2013). Electric vehicles and the electric grid: A review of modeling approaches, Impacts, and renewable energy integration. *Renewable and Sustainable Energy Reviews*, *19*, pp. 247-254. http://doi.org/10.1016/j.rser.2012.11.042

Rip, A., & Kemp, R. (1998). *Human choice and climate change: an international assessment* (Resources and technology, Vol. II). Battelle Press, Columbus.

Røpke, I., & Christensen, T. H. (2012). Energy impacts of ICT – Insights from an everyday life perspective. *Telematics and Informatics, 29*(4), pp. 348-361. http://doi.org/10.1016/j.tele.2012.02.001

Rotering, N., & Ilic, M. (2011). Optimal Charge Control of Plug-In Hybrid Electric Vehicles in Deregulated Electricity Markets. *IEEE Transactions on Power Systems*, *26*(3), pp. 1021-1029. http://doi.org/10.1109/TPWRS.2010.2086083

Rutherford, M. J., & Yousefzadeh, V. (2011). The impact of Electric Vehicle battery charging on distribution transformers. In *2011 Twenty-Sixth Annual IEEE Applied Power Electronics Conference and Exposition (APEC)*. pp. 396-400. http://doi.org/10.1109/APEC.2011.5744627.

Ryghaug, M., & Toftaker, M. (2014). A Transformative Practice? Meaning, Competence, and Material Aspects of Driving Electric Cars in Norway. *Nature and Culture*, *9*(2), pp. 146-163. http://doi.org/10.3167/nc.2014.090203.

Sachs, W. (1992). *For Love of the Automobile: Looking back into the history of our desires*. Calfornia: University of California Press.

Sahakian, M., & Wilhite, H. (2013). Making practice theory practicable: Towards more sustainable forms of consumption. *Journal of Consumer Culture*, *14*(1), pp. 25-44.

Sayer, A. (2009). Geography and global warming: can capitalism be greened? *Area*, *41*(3), pp. 350-353.

Schatzki, T. (1996). *Social practices: A Wittgensteinian Approach to Human Activity and the Social*. New York: Cambridge University Press.

Schatzki, T. R., Knorr-Cetina, K., & Savigny, E. von. (2001). *The practice turn in contemporary theory*. London; New York: Routledge.

Schick, L., & Gad, C. (2015). Flexible and inflexible energy engagements - A study of the Danish Smart Grid Strategy. *Energy Research & Social Science*, *9*, 51–59. http://doi.org/10.1016/j.erss.2015.08.013

Schick, L., & Winthereik, B. R. (2013). Innovating Relations-or why smart grid is not too complex for the public. *Science & Technology Studies*, *26*(3),pp. 82-102.

Schuitema, G., Anable, J., Skippon, S., & Kinnear, N. (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A: Policy and Practice*, *48*, pp. 39-49. http://doi.org/10.1016/j.tra.2012.10.004.

Schulte, I., Hart, D., & van der Vorst, R. (2004). Issues affecting the acceptance of hydrogen fuel. *International Journal of Hydrogen Energy*, *29*(7), pp. 677-685. http://doi.org/10.1016/j.ijhydene.2003.09.006.

Seyfang, G., & Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics*, *16*(4), pp. 584-603. http://doi.org/10.1080/09644010701419121.

Shafiei, E., Thorkelsson, H., Ásgeirsson, E. I., Davidsdottir, B., Raberto, M., & Stefansson, H. (2012). An agent-based modeling approach to predict the evolution of market share of electric vehicles: A case study from Iceland. *Technological Forecasting and Social Change*, *79*(9), pp. 1638-1653. http://doi.org/10.1016/j.techfore.2012.05.011.

Sheller, M., & Urry, J. (2006). The New Mobilities Paradigm. *Environment and Planning A*, *38*(2), pp. 207-226. http://doi.org/10.1068/a37268.

Shiau, C.-S. N., Samaras, C., Hauffe, R., & Michalek, J. J. (2009). Impact of battery weight and charging patterns on the economic and environmental benefits of plug-in hybrid vehicles. *Energy Policy*, *37*(7), pp. 2653-2663. http://doi.org/10.1016/j.enpol.2009.02.040.

Shove, E. (2003). *Comfort, Cleanliness and Convenience: The Social Organization of Normality*. Oxford: Berg Publishers.

Shove, E. (2009). Everyday practice and the production and consumption of time. In E. Shove, F. Trentmann, & R. Wilk (Eds.), *Time, Consumption and Everyday Life: Practice, Materiality and Culture.* pp. 17-33. New York: Berg.

Shove, E. (2010). Beyond the ABC: Climate Change Policy and Theories of Social Change. *Environment and Planning A*, *42*(6), pp. 1273-1285. http://doi.org/10.1068/a42282.

Shove, E., & Chappells, H. (2001). Ordinary consumption and extraordinary relationships: utilities and their users. In J. Gronow & A. Warde (Eds.), *Ordinary consumption*. London: Routledge.

Shove, E., & Pantzar, M. (2005). Consumers, Producers and Practices: Understanding the invention and reinvention of Nordic walking. *Journal of Consumer Culture*, *5*(1), pp. 43-64.

Shove, E., Pantzar, M., & Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and How it Changes*. London: Sage.

Shove, E., & Walker, G. (2010). Governing transitions in the sustainability of everyday life. *Research Policy*, *39*(4), pp. 471-476. http://doi.org/10.1016/j.respol.2010.01.019

Shove, E., & Walker, G. (2014). What Is Energy For? Social Practice and Energy Demand. *Theory, Culture & Society*, 263276414536746. http://doi.org/10.1177/0263276414536746

Shove, E., Watson, M., Hand, M., & Ingram, J. (2007). *The Design of Everyday Life*. Berg Publishers.

Shove, E., Watson, M., & Spurling, N. (2015). Conceptualizing connections: Energy demand, infrastructures and social practices. *European Journal of Social Theory*. http://doi.org/10.1177/1368431015579964

Sierzchula, W., Bakker, S., Maat, K., & van Wee, B. (2012). The competitive environment of electric vehicles: An analysis of prototype and production models. *Environmental Innovation and Societal Transitions, 2*, pp. 49-65. http://doi.org/10.1016/j.eist.2012.01.004.

Simic, D., Stark, J., Bäuml, T., & Link, C. (2014). Required range of electric vehicles – an analysis of longitudinal mobility data. *IET Intelligent Transport Systems*, *9*(2), pp. 119-127. http://doi.org/10.1049/iet-its.2013.0019

Situ, L. (2009). Electric Vehicle development: The past, present and future. In *3rd International Conference on Power Electronics Systems and Applications, 2009. PESA 2009*. pp. 1-3.

Skjølsvold, T. M., Ryghaug, M., & Berker, T. (2015). A traveler's guide to smart grids and the social sciences. *Energy Research & Social Science*, *9*, pp. 1-8. http://doi.org/10.1016/j.erss.2015.08.017

Southerton, D. (2003). Squeezing time: Allocating practices, coordinating networks and scheduling society. *Time & Society*, *12*(1), pp. 5-25.

Southerton, D. (2009). Temporal Rhythms: Comparing daily lives of 1937 with those of 2000 in the UK. In E. Shove, F. Trentmann, & R. Wilk (Eds.), *Time, Consumption and Everyday Life: Practice, Materiality and Culture*. pp. 49-63. Oxford, Berg.

Southerton, D. (2012). Habits, routines and temporalities of consumption: From individual behaviours to the reproduction of everyday practices. *Time & Society*, *22*(3), 335–355. http://doi.org/10.1177/0961463X12464228

Southerton, D., Chappells, H., & Van Vliet, B. (Eds.). (2004). *Sustainable Consumption: The Implications of Changing Infrastructures of Provision*. Cheltenham UK: Edward Elgar Publishing Limited.

Sovacool, B. K., & Hirsh, R. F. (2009). Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. *Energy Policy*, *37*(3), pp. 1095-1103. http://doi.org/10.1016/j.enpol.2008.10.005

Spaargaren, G., & Van Vliet, B. (2000). Lifestyles, Consumption and the Environment: The Ecological Modernisation of Domestic Consumption. *Environmental Politics*, *9*(1).

Sperling, D., & Gordon, D. (2009). *Two Billion Cars: Driving Toward Sustainability*. New York: Oxford University Press.

Spradley, J. P. (1979). *The Ethnographic Interview* (11.printing ed.). New York: Fort Worth: Holt, Rinehart and Winston.

Spurling, N., & McMeekin, A. (2014). Interventions in practices. In *Social Practices, Intervention and Sustainability - Beyond behaviour change*.

Spurling, N., McMeekin, A., Shove, E., Southerton, D., & Welch, D. (2013). *Interventions in practice: re-framing policy approaches to consumer behaviour* (Sustainable Practices Research Group). Sustainable Practices Research Group: Sustainable Practices Research Group.

Stake, R. E. (1994). Case Studies. In *Handbook of Qualitative Research* (N.K. Denzin & Y.S. Lincoln, pp. 236-247). Thousand Oaks, Sage Publications.

Stephan, C. H., & Sullivan, J. (2008). Environmental and Energy Implications of Plug-In Hybrid-Electric Vehicles. *Environmental Science & Technology*, *42*(4), pp. 1185-1190. http://doi.org/10.1021/es062314d.

Stern, P. C. (2000). Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues*, *56*(3), pp. 407-424.

Strengers, Y. (2012). Peak electricity demand and social practice theories: Reframing the role of change agents in the energy sector. *Energy Policy*, *44*, 226–234. http://doi.org/10.1016/j.enpol.2012.01.046.

Strengers, Y. (2013). *Smart Energy Technologies in Everyday Life - Smart Utopia?* Basingstoke: Palgrave Macmillan.

Strengers, Y., & Maller, C. (2014). *Social Practices, Intervention and Sustainability: Beyond behaviour change*.

Strengers, Y., Nicholls, L., & Maller, C. (2014). Curious energy consumers: Humans and nonhumans in assemblages of household practice. *Journal of Consumer Culture*, *14*(1).

Thagaard, T. (2004). *Systematik og indlevelse – en indføring i kvalitativ metode*. København: Akademisk fprlag.

Throndsen, W. (2013). Constructing the Norweigan smart grids: To fix what is not broken?, pp. 1831-1840.

Tran, M., Banister, D., Bishop, J. D. K., & McCulloch, M. D. (2012). Realizing the electric-vehicle revolution. *Nature Climate Change*, *2*(5), pp. 328-333. http://doi.org/10.1038/nclimate1429

Urry, J. (2004). The “system”of automobility. *Theory, Culture & Society*, *21*(4-5), pp. 25-39.

Urry, J. (2007). *Mobilities*. Cambridge: Polity Press.

van Bree, B., Verbong, G. P. J., & Kramer, G. J. (2010). A multi-level perspective on the introduction of hydrogen and battery-electric vehicles. *Technological Forecasting and Social Change*, *77*(4), pp. 529-540. http://doi.org/10.1016/j.techfore.2009.12.005

Verbong, G. P. J., & Geels, F. W. (2010). Exploring sustainability transitions in the electricity sector with socio-technical pathways. *Technological Forecasting and Social Change*, *77*(8), pp. 1214-1221. http://doi.org/10.1016/j.techfore.2010.04.008

Walker, G. (2014). The dynamics of energy demand: Change, rhythm and synchronicity. *Energy Research & Social Science*, *1*, pp. 49-55. http://doi.org/10.1016/j.erss.2014.03.012

Warde, A. (2005). Consumption and Theories of Practice. *Journal of Consumer Culture*, *5*(2), pp. 131-153. http://doi.org/10.1177/1469540505053090.

Watson, M. (2012). How theories of practice can inform transition to a decarbonised transport system. *Journal of Transport Geography*, *24*, pp. 488-496. http://doi.org/10.1016/j.jtrangeo.2012.04.002.

Wolsink, M. (2012). The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews*, *16*, pp. 822-835. http://doi.org/10.1016/j.rser.2011.09.006.

Zhang, T., Gensler, S., & Garcia, R. (2011). A Study of the Diffusion of Alternative Fuel Vehicles: An Empirical Agent-Based Model of Attitude Formation and Change. *Journal of Product Innovation Management*, *28*(2), 152-168. http://doi.org/10.1111/j.1540-5885.2011.00789.x.

9. FULL-LENGTH PAPERS

From:
Hansson, L. ; Holmberg, U. ; Brembeck, H. (Eds.)(2013).
Making sense of consumption. Selections from the 2nd Nordic Conference on Consumer Research 2012.
Göteborg: Centre for Consumer Science, University of Gothenburg. ISBN: 978-91-974642-6-0.
Available online at http://hdl.handle.net/2077/34508

Households in the smart grid – existing knowledge and new approaches

Toke Haunstrup Christensen, Kirsten Gram-Hanssen & Freja Friis

For decades, electricity has generally been produced and available in western societies whenever consumers needed it and consumers could consume without thinking about it. This may not be the case in the future as new relationships between electricity consumers and producers are emerging. Electricity producers as well as transmission and network operators are increasingly interested in influencing the timing of when and how consumers use electricity, and in micro-generation by households (for instance from small wind turbines or photovoltaic solar panels). These changes are closely related to the so-called smart grid debate. In this chapter we will describe and analyse some of these technological changes within the electricity system, which is promoted by different actors, and we will discuss how this may influence the everyday life of consumers as well as the reverse; how everyday practices of consumers may influence this socio-technical system.

What is the smart grid?

It has already been expected for some years that the future of electrical grids will involve increasing use of information and communication technologies (ICTs) at all levels of the electricity system, including the production, distribution and consumption sides. The main drivers are new possibilities within ICT and new challenges within the energy system. One of these is the challenge of balancing electricity consumption and electricity production. Typically, most households have high electricity consumption at particular times, e.g. the peak between 17:00-19:00 in the evening when people return from work and turn on their electrical appliances in the home and start preparing dinner. Providing and distributing enough electricity for this type of peak is expensive, technically demanding and environmentally problematic. A possible solution could be to use ICT to better balance electricity production and consumption. Furthermore, introducing more renewable energy such as photovoltaic solar panels and wind power into the system implies that electricity production may fluctuate even more.

"Smart grid" is a term used to describe this future responsive and balanced energy system. Comparing similarities and differences between the approach to smart grids in the EU and the US, Coll-Mayor et al. (2007) show how contextualized the smart grid discussion is. Questions related to energy security and policy, including dependence on own vs. imported energy, type of energy market, type of existing energy production system, environmental and climate issues etc., are all influencing what grid developments are needed or could be expected.

Even though there is some agreement on what is meant by the smart grid, the term is an often cited catchphrase, which is vague and open in its definitions. One attempt to be explicit about what is meant by smart grid is found in Wissner (2011). According to Wissner, central factors are: liberalization of the telecommunication market with new competitors searching for new business models together with technological innovations, including appliance-integrated microchips, digitalization of networks and all sorts of wireless communication which enable different types of ambient intelligence including automation of everyday processes and activities. Thus, a possible future scenario of the smart grid includes a network of central power plants, wind turbines and other decentralized power generation, combined in an intelligent structure with houses that can produce, use and store energy, depending on the overall system requirements.

These changes in the power grid are inscribed in a long-term perspective, as the existing energy system is characterized by stability and lock-ins in both social organization and technology. Furthermore, based on a transition theoretical perspective with a multilevel framework on major technological transitions in infrastructures, Verbong and Geels (2010) show that other possible futures might be alternatives to the smart grid. For example the "super grid", a grid where all European countries are linked together and electricity is transmitted over long distances rather than adjusted to local energy resources. However, as demonstrated in this chapter, there are already many existing activities from different stakeholders that aim to promote the smart grid in order to overcome the inertia of the existing system.

Households in the smart grid

A very important element in the smart grid is the households and the consumers, who are expected to have a much more active role in the future energy system. This can include household-based electricity production, energy storage in batteries or as heat in the house and "flexible electricity consumption" (load management). The latter implies moving electricity consumption by moving energy consuming activities like electric heating, charging of electric vehicles or laundering to times with high electricity production or "peak shaving", i.e. shifting demand from "peak times" to times with lower demand. Load management in particular implies the active participation of consumers. Not all types of electricity consumption are suitable for load management; watching television and lighting, for example, cannot be postponed. Therefore, the focus in these areas should remain on efficient technologies to reduce consumption. Both energy efficiency of appliances and load management are important approaches in reducing CO_2 emissions (Vidalenc and Meunier 2011).

As it seems that smart grids in some form will be part of the future electricity system, and as consumers have a prominent position in the conceptualizations of the future smart grid, it is important to study the role and consequences of the smart grid for the future everyday life of consumers, as well as the opposite: how the everyday life of consumers might influence the smart grid. In the following we will first briefly discuss how consumer practices in changing socio-technical systems can be understood. Then follows a review of smart grids activities in Denmark as an exemplification of the type of activities that are occurring and how households are included in these activities. Then follows a section with a specific focus on electric vehicles, which are expected by many actors to play a particularly important role in the smart grid. Based on the review and the discussion of electric vehicles, we conclude by discussing the most relevant research questions and problems related to this possible future, from a consumption research perspective.

Understanding consumer practices in socio-technical systems

Consumers' sense-making of everyday consumption is not done in a vacuum. Rather, their consumer practices are interwoven with socio-material systems, linking production and consumption together and including other social actors as well as material objects. Electricity consumption is a particular type of consumption. Together with other types of consumption based on large socio-technical infrastructures such as heat and water consumption, electricity consumption is on one hand invisible and inconspicuous, depending on routines and habits, and on the other hand a fundamental prerequisite of our modern way of living. It can be argued that we do not *consume* electricity as such, but rather perform practices through which electricity is consumed during the use of household appliances. Everyday practices of cooking, laundering, watching television etc. must be seen in relation to the production system of all of the material objects used in these practices, as well as in relation to the production of the electricity, which is a fundamental element of performing the practices (Vliet, Chappells and Shove 2005). Practice theory was introduced into consumer studies some years ago (Shove and Pantzar 2005; Warde 2005), and since then there has been a growing body of research using practice theory to understand everyday practices and their connection to energy consumption (Gram-Hanssen 2010a, 2010b; Hargraves 2011; Strengers 2010, 2011). This approach focuses on the collective aspects of practices, seeing the individual as a carrier of practices rather than as an individual deciding what to do. Furthermore, practices are seen as guided by competences, rules, technology and meanings. This approach of practice theory is thus well suited for understanding how socio-technical systems, e.g. electricity production, influence the everyday practices of households. In this chapter we are interested in the changes that are taking place within the production side of the electricity grid, promoted by different types of actors, as it seems that these will have a significant impact on the consumer side of this socio-technical system, specifically the everyday practices performed by individual households.

Danish household smart grid activities – seen in a European context

As described in the introduction, the national context, including the local electricity system and energy policy, is decisive for challenges and solutions within smart grid development. In this section, we will give a brief overview of the Danish household smart grid activities, including the rollout of advanced metering infrastructure (smart meters) as well as previous and current smart grid projects related to households. We begin with a short introduction to the Danish electricity system, which forms an important context for understanding the Danish smart grid activities related to households.

The Danish electricity system

Fossil fuels, mainly coal and natural gas, dominate Danish electricity production as primary energy sources, and about half of the electricity comes from combined heat and power production (Danish Energy Agency 2011). However, by 2020, the Danish energy agreement aims to shift 50% of electricity production to wind power. This increasing share of fluctuating wind power in the electricity system poses new challenges in relation to balancing the input and output of the electricity grid. Wind power production already exceeds domestic electricity consumption at times with high wind speeds and low domestic consumption. This has given rise to an interest in developing solutions to manage the consumption side. Through load management, electricity consumption can either be delayed in situations of low wind power generation or moved forward in cases of excess wind power. Hitherto, the focus has particularly been on electric vehicles and electric heating of buildings as objects of load management.

The metering infrastructure

The rollout of "smart meters" is regarded as pivotal for the development of an advanced metering infrastructure that is expected to be the backbone of the future smart grid. Smart meters are electric meters that enable two-way communication between the meter and other actors in the electricity system (e.g. distribution system operators) and record electricity consumption in intervals of an hour or less. Smart meters are typically a technological prerequisite for feedback to customers about their electricity consumption and for load management. Furthermore, the remote reporting feature of smart meters is regarded as a more cost-effective alternative to the traditional meters that included considerable administrative costs in relation to reading the meters.

A 2011 survey by the Austrian Energy Agency of the status of the national regulation and implementation of smart meters in the EU27 Member States and Norway (Renner et al. 2011) shows great differences between the European countries. In some countries a mandatory rollout of smart meters to all customers is already in place or in preparation (e.g. Italy, France, Malta and Spain). However, most Member States do not yet have a mandatory rollout in place, even though some countries do already have a high degree of implementation of smart meters. Denmark is an example of this: by 2011, an estimated 50% of Danish households already had smart meters and remote reading installed (Renner et al. 2011). With the rollout of smart meters, one solution in relation to "activate" consumers is to regulate energy consumption using dynamic electricity prices. Today, households' electricity consumption is paid for according to average expenses and includes a considerable element of tax. Dynamic pricing would presumably give a more precise signal of "real-time" expenses and might mobilize consumers by increasing the incentives to change temporal consumption patterns.

Status of Danish household smart grid activities

In this section we present a brief survey of the Danish household smart grid activities based on a study by the Joint Research Centre (2011) and our own review of existing projects. The survey shows (table 1) that load management is the area that attracts the most attention in relation to Danish research & development and demonstration projects, particularly in relation to electric heating (heat pumps or direct electric heating) and charging of electric vehicles. Both areas are expected to become increasingly important for the Danish electricity system in the coming years, due to an expected substitution of oil-fired central heating with heat pumps in single-family houses outside district heating areas and an expected substitution of traditional cars with electric vehicles. Both are seen as part of the change from fossil fuels to carbon-neutral fuels and as a prerequisite in itself for building the needed storage capacity in the future smart grid with a high share of wind power. However, a number of projects also have a more general approach to residential electricity consumption, i.e. not focusing on one particular area.

As noted by Nyborg and Røpke (2011, 7), the question of who should manage consumption in order to provide flexibility – the consumers themselves or the electricity companies through remote control – is one of the core issues in the discussion about load management. The Danish load management projects reflect this diversity. Some projects focus on *automated remote management* of appliances. Other projects focus on *motivating consumers to change their practices* (e.g. defer their laundry or dishwashing) in response to information about real-time electricity prices.

	Electricity saving	**Load management**	**Micro-generation**	**Power capacity**	**Other**
Heating/air cond.		* Price-sensitive electricity cons. in households * EcoGrid EU * eFlex * Intelligent remote control of heat pumps * Trials with heat pumps on spot agreements			
Cooling					
Laundering					
Cooking					
Lighting & other appliances					
Transport		* EDISON * EcoGrid EU * eFlex * Intelligent charge stands * Test en elbil			* Test en elbil * Better Place * Etrans
Household electr. cons. in general	* ConsumerWeb * EcoGrid EU * Intelligent home * EnergyFlexHouse * Feedback-motivated energy savings * Several “feedback light” solutions in relation to smart meters (provided by DSOs)	* eFlex * iPower * Energy Forecast * FlexPower * EnergyFlexHouse	* EnergyFlexHouse		* IMPROSUME
Other					* Innovation Fur

Table 1: Danish household smart grid projects by type of smart grid activity and consumption area

An example of automated load management is the “Intelligent remote control of heat pumps” project, which aims to develop and demonstrate an intelligent remote control system for individual heat pumps through trials involving up to 300 households (http://www.styrdinvarmepumpe.dk). Examples of active involvement of consumers are the eFlex project (by DONG Energy) and the FlexPower project (by SEAS-NVE in cooperation with Ea Energianalyse and others). The eFlex trial finished in 2012 and involved about 120 households (predominantly households with heat pumps, but also a few with electric vehicles as well as some without heat pumps or electric vehicles). The test families were equipped with the home energy management system GreenWave Reality, which enabled feedback at appliance level, apps for smart phones and remote control of appliances. During the test period, the families were offered real-time dynamic prices, which meant that the electricity price varied by up to 1 DKK/kWh (the normal Danish electricity price is about 2 DKK/kWh). The project showed, among other things, some potential for load management in relation to heat pumps, but also limitations to this potential such as in periods of extraordinarily cold weather. Finally, some projects included both automated remote management and active involvement of consumers. One example of this is the research project “Price-sensitive electricity consumption in households”, which included about 500 households divided into one control group and three test groups, including a test group with automated remote control of their direct electric heating system and a group that was notified about the next day’s electricity prices by e-mail or SMS on a daily basis. The study showed that only the first test group had realized actual economic savings through load management (Togeby and Hay 2009).

Electric vehicles are considered by many actors to play a particularly important role in the future Danish smart grid. The idea is that with the (expected) penetration of electric vehicles, these will represent considerable storage capacity for electricity. At times with high power production (e.g. due to high wind speeds), the electricity surplus (or some of it) can be stored in the batteries of electric vehicles through intelligent management of the charging. At the time of the COP15 summit in Copenhagen, two major electric vehicle demonstration projects were launched: “Better Place” and “Test-an-EV”. Both projects aimed at introducing electric vehicles to the Danish market and promoting sales, the projects differ with regard to the basic battery charging design. While the “Test-an-EV” project made use of traditional electric vehicles, the “Better Place” project developed a design with switchable batteries; thus, the car battery could be recharged at home, at the work place or at another charge station (as with "traditional" electric vehicles), or the depleted batteries could be replaced with new, fully-charged batteries at special designed "battery switch stations". The latter solution was developed in order to solve the problem of limited battery capacity and the problem of time-consuming recharging of batteries. "Test-an-EV" took another approach to the problem of limited driving distance between recharge, as they have been building a network of "Quick Charge" stations across Denmark. At these stations, electric vehicles can be recharged in only 20-40 minutes (compared to a normal recharging typically taking up to 5-6 hours).

In spring 2013, Better Place went bankruptcy due to failing car sales, wheres the Test-an-EV project is still running. Both projects relate their activities to the aim of developing a smart grid where electric vehicles play a particularly important role in load management. However, until now with a main focus on popularizing the electric vehicle and promoting sales.

With regard to electricity saving and feedback, almost all customers with a smart meter have access to some kind of feedback services, although the extent of these services varies considerably among electricity companies. The minimum service, provided by nearly all companies, is offering the customers the possibility of accessing data about their household's electricity consumption based on hourly readings. In addition to this, some also offer services like applications (apps) for smart phones that can be used to monitor the household's electricity consumption, or receiving alerts by SMS or e-mail if the electricity consumption is higher or lower than usual. Even though in principle almost half of Danish households have access to some kind of feedback about their household's total electricity consumption, it is still uncertain how great an impact (if any) this has had in terms of actual electricity saving. International research suggests that there is little evidence that this type of feedback to customers will automatically achieve a significant reduction in energy demand (Darby 2010).

While the main focus of the Danish household smart grid projects is on electricity saving and load management (table 1), only one project (the EnergyFlexHouse project) includes tests of household-based "micro-generation" technologies such as photovoltaic solar panels, and no projects focus on households as suppliers of "power capacity" to the grid in situations with a deficit of electricity (e.g. electric vehicles delivering electricity back to the grid). While most of the load management projects focus on electric heating or electric vehicles, electricity saving projects in general have a broad focus on electricity consumption in households.

The number of smart grid projects in Denmark is high compared with other European countries, including Norway (Joint Research Centre 2011). The size of projects varies considerably, but most projects are relatively small, with a total budget of only a few million DKK. However, the list of projects also includes a few large-scale demonstration projects (e.g. the previously mentioned Better Place and Test-an-EV). The largest project is the EcoGrid EU project, launched in 2011 and running until 2015, with a total budget of 21 million euro. EcoGrid EU is expected to be the largest European full-scale testing of smart grids so far (Nyborg and Røpke 2011). The project is based on the island of Bornholm and includes many different smart grid solutions (e.g. "intelligent charging" of electric vehicles and load management in general) and involves at least 2,600 households (Energinet.dk 2012).

The electric vehicle: an important technology in the smart grid

As electric vehicles are expected by many actors to play a particularly important role in the future smart grid, and as they are an emerging technology, this section will present the latest developments in electric vehicles (including challenges and advantages) and review existing studies on consumer adoption of electrical vehicles.

The state of electric vehicles: advantages and challenges

To establish electric vehicles as a serious alternative to traditional internal combustion engine cars, manufacturers have primarily focused on improving performance. Companies like Toyota, Citroën, Peugeot, Honda, Mitsubishi, Renault etc. are at the forefront of developing different prototypes of electric vehicles. Now that electric vehicles are competitive with traditional combustion engine cars in relation to acceleration and car size, the focus has turned to solving two critical issues: 1) the driving distance per recharge, and 2) production costs. The vehicle-to-grid configuration of electric vehicles features three operation elements: a power connection to the grid, a control/communication device and a meter (Sovacool and Hirsh 2008). To solve problems with the limited driving distance, a geographically distributed recharge infrastructure is necessary (like the "Quick Charge" stations of the Test-an-EV project or the "battery switch stations" of the Better Place project). Infrastructural changes progress slowly as the incorporation of electric vehicles into the market is a long-term goal. This means that electric vehicles will not be fully competitive with traditional combustion cars until a recharge network has been established, so that consumers can cover longer travel distances (Sovacool and Hirsh 2008).

Also, the interface to the grid is attracting more focus and standardization is becoming an important issue. The European Commission has issued a mandate to ensure consistent standards within the EU, and while this was previously driven by the utilities, the car manufacturers are now also taking part in that process.

Electric vehicles have many potential advantages. Some arguments for electric vehicles are their mechanical simplicity, ease of use and perception as environmentally out-performing traditional cars (Dickerman and Harrison 2010). "Soft" characteristics such as improving comfort and safety are also becoming a selling point (Sovacool and Hirsh 2008). In this regard, the main barriers facing electric vehicles are not only technical or economic; significant factors could also be social and cultural values, business practices, political interests etc. (ibid).

Consumer adoption of electric vehicles

The literature on consumer adoption of electric vehicles is dominated by the rational choice approach and thereby a focus on economic and instrumental barriers and how these can be translated into policy (Sovacool and Hirsh 2008). However, vehicle trials are beginning to see uptake processes that are more complex and slower than the economic approaches suggest. A study by Heffner et al. (cited in Sovacool and Hirsh 2008) based on interviews with early purchasers of electric vehicles in California found that savings from fuel efficiency constituted only a small part of the reason for adopting electric vehicles. Accordingly, some studies advocate a better understanding of consumer preferences, habits and incentives in the adoption of electric vehicles. Analyses of consumer adoption claim that consumers in general have different patterns of adoption and use, have different attitudes, relate different meanings to electric vehicles and evaluate the attributes of the car differently.

Correspondingly, a study of driving patterns and electricity supply systems in the US (Weiller 2011) demonstrated significant variation between different regions and between different states. This led to a broader conceptualization of segmentations, with the conclusion that there is more than one group of early adopters of electric vehicles, as well as a variety of mainstream consumer segments, each with different motivations and degree of propensity to adopt different types of technology (Anable et al. 2011).

There are also differing post-purchase adoption issues with electric vehicles. An ethnographic study from the UK (Brady 2010) points out that adopters of electric vehicles are challenged by a lack of support with regard to servicing and maintenance of the car, and not by expected issues such as limited recharging facilities. The study concludes that the current market for electric vehicles consists predominantly of multi-vehicle suburban households, who do not mind DIY repairs and servicing. Furthermore, the study describes electric vehicles as a niche technology, as those who adopt electric vehicles can be categorized into classical innovators and/or early adopters. According to the study, drivers are citizens with a high appreciation of energy issues seeking to reduce energy use in their everyday lives (Brady 2010). For example, the electric vehicle drivers express a feeling of wellbeing and less guilt.

Similarly, Jansson (2009) concludes that potential electric vehicle consumers have either a strong pro-environmental orientation or a strong inclination to own this new technology. In general, consumers prefer cars that contribute to their self-realization process. This tendency can be assumed to influence the factors that make electric vehicles socially acceptable (Anable et al. 2011).

Accordingly, factors like information, demonstration and opportunities to test electric vehicles in everyday life could help consumers with purchase decisions and assure them that electric vehicles are compatible with their daily needs. Routines in which electric vehicles differ from conventional vehicles, such as charging or re-routing for limited driving distances, should be designed, communicated and supported by means of appropriate technical devices so that they are easy to manage in daily life. The conclusion is that the range of electric vehicle models should be oriented towards various user groups, so that the different user groups will be able to select the model which is most appropriate for them (Peters et al. 2011).

Despite a wider acceptance of the influence of social and behavioural factors on the adoption of electric vehicles, car manufacturers still emphasize the electric vehicle as a mainstream car in their communication to the public, portraying novel hardware as neither unfamiliar nor sensational, but as safe, familiar and comfortable. This reflects the perception of consumers as close-minded about new technologies. Instead of embracing new energy technologies, it is thought that consumers rely on notions of tradition and familiarity when they make consumer choices, especially when dealing with hardware that requires high capital investment (Sovacool and Hirsh 2008).

Concluding on future challenges: understanding consumers in the smart grid

The smart grid is an emerging socio-technical system. Many ideas and expectations are associated with the term, but examples of large-scale deployment of smart grid solutions are few so far. Up to now, advanced metering systems (smart meters) have been the technology with the largest distribution in Europe, including Denmark. However, apart from simple and mostly web-based feedback services and remote readings of customers' electricity consumption, smart meters for more advanced applications on a larger scale have not been seen.

While the actual, full-scale employment of smart grid solutions is still limited, the number of research, development and demonstration projects is manifold. Different concepts and strategies are developing, particularly within the areas of energy saving (with feedback to customers about their electricity consumption) and load management.

The high degree of "interpretive flexibility" associated with the "smart grid" means that it is imbued with very different and sometimes conflicting interpretations of how solutions should be designed. One example is household load management and the question of who should manage and control consumption in the household. Some argue for remote control with as little active participation from residents as possible, while others work with designs that aim to involve residents actively through continuous information about real-time prices. Behind these different approaches lie different ways of conceptualizing residents and their interests.

Hitherto, initiatives within the development of smart grid solutions have tended towards a technology-centred design approach. New solutions are designed with a primary focus on the technical needs of the future electricity system, e.g. load management, and only a secondary focus on the interests and characteristics of the end-users. As a result, the end-user context is in most projects only weakly integrated in the design.

The technology-centred design approach involves the risk that possible "un-intended" side-effect uses might undermine the intended, systemic benefits of developing smart grid solutions. One example could be electric vehicles that are believed to play a key role in relation to "peak shaving" and the problem of fluctuating renewable energy production. However, few projects have studied the actual charging pattern of owners of electric vehicles. A potential problem could arise if owners recharge their cars when they come home from work in the early evening, which would coincide with the peak load between 17:00 and 19:00. In this example, the charging pattern would actually exacerbate the peak-load problem.

In this chapter, we have described how smart grid solutions might form a possible future scenario for a climate friendly energy system, while also describing the way that consumers should be assigned a central role in realizing the smart grid. However, as demonstrated through the examples of Danish projects and the review of consumer responses to electric vehicles, it is also apparent that there are many unanswered questions and challenges to the realization of the smart grid. Establishing the smart grid is about making changes in a large technical system, the existing energy system, which forms a huge complex of integrated economic, technical, institutional and cultural structures with vested interests from many actors. Up until now, the focus of research has been on the technical and economic aspects of developing this new infrastructure. However, we want to emphasize the importance of the cultural and social structures of the everyday lives of consumers as a decisive element in this transition. This importance is mutual: the smart grid will not be able to work if consumers' everyday practices are not integrated adequately into the solutions. But also vice versa: there are many relevant questions to ask of the smart grid solutions from a consumer policy perspective. These include questions of energy security, data security and anonymity in relation to the flow of data on household consumption, as well as rights and obligations related to the new possible roles of "prosumers", i.e. households being energy consumers and producers at the same time.

References

Anable, Jillian, Stephen Skippon, Geertje Schuitema, and Neale Kinnear (2011), "Who will adopt electric vehicles? A segmentation approach of UK consumers," paper presented at the ECEEE 2011 Summer Study, Belambra Presqu'île de Giens, France.

Brady, Joanne (2010), *Electric Car Cultures: An ethnography of the everyday use of electric vehicles in the UK*, Durham, UK: Durham University.

Coll-Mayor, Debora, Mia Paget, and Eric Lightner (2007), "Future intelligent power grids: Analysis of the vision in the European Union and the United States," *Energy Policy*, 35 (?), 2453-2465.

Danish Energy Agency (2011), *Energy Statistics 2010*, Copenhagen: Danish Energy Agency.

Darby, S. (2010), Smart metering: what potential for householder engagement? *Building Research and Information*, 38(5): 442-457

Dickerman, Larry and Jessica Harrison (2010), "A new car, a new grid," *IEEE Power & Energy Magazine*, 8 (2), 55-61.

Energinet.dk (2012), "EcoGrid EU," http://energinet.dk/en/forskning/EcoGrid-EU/sider/EU-EcoGrid-net.aspx/

Gram-Hanssen, K. (2010a), Residential heat comfort practices: Understanding users. *Building Research and Information*, 38(2), 175-186.

Gram-Hanssen, K. (2010b), Standby consumption in households analysed with a practice theory approach. *Journal of Industrial Ecology*, 14(1), 150-165.

Hargreaves, T. (2011), Practice-ing behaviour change: Applying social practice theory to pro-environmental behaviour change. *Journal of Consumer Culture*, 11(1), 79-99.

Jansson, J. (2009), *Car(ing) for our environment? Consumer eco-innovation adoption and curtailment behaviours: the case of the alternative fuel vehicle*. Umea School of Business, Sweden.

Joint Research Centre (2011), *Smart Grid projects in Europe: lessons learned and current developments*, Luxembourg: Joint Research Centre and European Union.

Nyborg, Sophie and Inge Røpke (2011), "Energy impacts of the smart home – conflicting vision," paper presented at the ECEEE 2011 Summer Study, Belambra Presqu'île de Giens, France.

Peters, Anja, Raphael Agosti, Mareike Popp, Bettina Ryf (2011), "Electric mobility – a survey of different consumer groups in Germany with regard to adoption," paper presented at the ECEEE 2011 Summer Study, Belambra Presqu'île de Giens, France.

Renner, Stephan, Mihaela Albu, Henk van Elburg, Christoph Heinemann, Artur Lazicki, Lauri Penttinen, Francisco Puente and Hanne Sæle (2011), *European Smart Metering Landscape Report. SmartRegions Deliverable 2.1*, Vienna: Austrian Energy Agency.

Shove, E and Pantzar, M. (2005), Consumers, Producers and practices. Understanding the invention and reinvention of Nordic walking. *Journal of Consumer Culture*, Vol. 5 (1): 43-64

Sovacool, Benjamin K. and Richard F. Hirsh (2009), "Beyond Batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition," *Energy Policy*, 37 (3), 1095-1103.

Strengers, Y. (2010), Air-conditioning Australian households: The impact of dynamic peak pricing, *Energy Policy*, Volume 38, Issue 11, November 2010, Pages 7312-7322

Strengers, Y. (2011), Beyond demand management: co-managing energy and water practices with Australian households. *Policy Studies*, 32(1), 35-58.

Togeby, Mikael and Camilla Hay (2009), *Prisfølsomt elforbrug i husholdninger. Slutrapport fra PSO projekt 2006 1 6320*, Copenhagen: EA Energianalyse.

Verbong, Geert P. J. and Frank. W. Geels (2010), "Exploring sustainability transitions in the electricity sector with socio-technical pathways," *Technological Forecasting & Social Change*, 77 (8), 1214-1221.

Van Vliet, B., H. Chappells and E. Shove (2005), *Infrastructures of Consumption: Environmental Innovation in the Utility Industries.* London: Earthscan

Vidalenc, Eric and Laurent Meunier (2011), "Smart grid versus energy efficiency: Which one first?" paper presented at the ECEEE 2011 Summer Study, Belambra Presqu'île de Giens, France.

Warde, A (2005), Consumption and Theories of Practice. *Journal of Consumer Culture*. Vol 5(2) 131-153.

Weiller, Claire (2011), "Plug-in hybrid electric vehicle impacts on hourly electricity demand in the United States," *Energy Policy* 39(6), 3766-3778.

Wissner, Matthias (2011), "The Smart Grid – A saucerful of secrets," *Applied Energy* 88 (7), 2509-2518.

Integration of smart grid technologies in households – how electric vehicles and dynamic pricing change social practices in everyday life

Freja Friis
Danish Building Research Institute
Aalborg University Copenhagen
A.C. Meyers Vænge 15
DK-2450 Copenhagen SV
Denmark
frf@sbi.aau.dk

Kirsten Gram-Hanssen
Danish Building Research Institute
Aalborg University Copenhagen
A.C. Meyers Vænge 15
DK-2450 Copenhagen SV
Denmark
kgh@sbi.aau.dk

Keywords

household consumption, sustainable development, smart grid, behavioural change, electric vehicles, temporal trends, user behaviour, user perspective, end-use consumption, everyday life, incentives, social practice theory, dynamic pricing

Abstract

This article considers the interplay between new smart grid technologies and households' everyday practices. The research focuses on how Electric Vehicles and Dynamic Pricing influence Danish households' everyday life and how these technologies constitute and change routines and practices of consumption.

The basic assumption is that new technologies influence social practices in households' everyday life. The empirical material, mainly consist of qualitative interviews with Danish households who had test-driven Electric Vehicles and participated in Project Dynamic Pricing, is analysed with the analytical concept offered by the Social Practice Theory.

Overall, the case-study demonstrates that the smart grid technologies influence the 'way of driving' and changed the temporal patterns of consumption in the families during the test period. The investigation contribute to a more complex and multi-facetted consideration of the interplay between households' social practices and new smart-grid technologies and thereby helping to fill out the lack of research on the integration of peak-shaving technologies in the end-user design.

Introduction

Current energy systems face the challenge of including more renewable energy sources (RESs) in their supply. To manage the transition to a more sustainable energy system based on fluctuating energy production, a new highly complex, self-balancing energy system called 'Smart Grid' has been initiated. Smart grid is a process of defining and developing intelligent control technologies to control and coordinate flexible consumption in order to maintain a balance between production and consumption in the overall electricity system.

RESs increase the demand for new consumption patterns by the fact that photovoltaics (PVs) and wind power are fluctuating, dependent on the availability of sunshine and wind. In Denmark, wind power is put forward as a main RES and is expected to increase substantially by 2020. The typical highlighted future scenario of a critical grid load in Denmark is the particular (consumption) peak between 5–7 pm in the afternoon. To solve this challenge, the intelligent control technologies are envisioned as a possible solution to 'peak-shave' through flexible electricity management in the households.

In general, the establishment of smart grid has focused on technical and economic challenges and advantages (Christensen et al. 2013), but also user involvement and user-oriented innovation have emerged within the concept of smart grid. This perspective is pursued among consumption researchers, emphasising that social and cultural perspectives on consumption are inevitable for developing a sustainable energy system (Darby 2010, Gram-Hanssen 2011a, Gram-Hanssen 2011b, Nyborg and Røpke 2011). Hence, recent research findings show that constituted social practices are as least as important as the efficiency of technology (Darby 2010, Gram-Hanssen 2013, Gram-Hanssen 2011b, Nyborg and Røpke 2011, Axsen and Kurani 2010).

From this point of view, households and consumers are, as prominent 'actors', expected to play a more active role in order to maintain the balance between consumption and production in the grid. Concrete examples of flexible energy production and consumption are: household-based production, their ability to store energy in batteries or by heating houses and by load management facilitated by moving energy consumption like electric heating, charging of electric vehicles (EVs) or moving laundry activities (Christensen et al. 2013, Nyborg and Røpke 2011). This investigation focuses specifically on EVs and their expected potential for maintaining a balance in the grid through load management that can either delay or forward consumption in relation to the generation of wind power in the energy system.

Through an in-depth case study, our purpose is to explore how social practices, in a particular context, are changed and constituted in households after obtaining and integrating EVs and Dynamic Pricing in their everyday. The aim is to provide some new insights into how consumption is organised and how new consumption patterns influence the social worlds of households that manage to integrate those two projects into their everyday life. Based on the conviction that cultural and social structures of everyday life are decisive elements in the transition to a low-carbon energy system, this article aims to explore: *How do smart grid technologies as EVs and Dynamic Pricing change and constitute social practices in households' everyday life?*

Methods and empirical material

CASE STUDY

The case study consisted of the two smart-grid/peak-shave demonstration projects 'Test-an-EV' and 'Project Dynamic Pricing', where 18 families from two small towns in the South of Jutland participated. Both projects ran from May to October 2012 (5 months) and were the first demonstration projects in a Danish context with participants who combined EV driving with Dynamic Pricing in their everyday life.

"Test-an-EV" is facilitated by the mobility operator CLEVER, which is owned by the utilities SE and SEAS-NVE[1]. CLEVER provides EVs through financing services, operation, advice and environmental optimisation e.g. by building a nationwide charging infrastructure network[2]. CLEVER's mission is "to create a strong synergy between environmental concerns and mobility by promoting EVs and ensuring that they are charged intelligently" (www.clever.dk). The overall aim of CLEVER is to play a significant role in developing balancing smart-grid solutions with regard to EVs (ibid.).

"Test-an-EV" is promoted as Europe's largest EV research project, where 1,600 Danish households from 24 municipalities all over the country test 200 EVs for a 3-month period. The project was launched in December 2010 and will end primo 2014. CLEVER terms the participating households who test-drive the EVs 'test pilots'. CLEVER outlined requirements for the families involved, e.g. the families must already own a car, as the project was not allowed to create more car-driving. Further, for three months of free test-driving, the test pilots were, committed to the following obligations or 'rules': daily blogging (on the website www.testenelbil.dk), to log data in a driver's log book (for each drive undertaken), installation of a load cable in their house, to share their personal experience (e.g. through official meetings) in general and to pay the expenses of their recharge at home[3]. Moreover, CLEVER installed a data logger in every test car to register battery technology, driving patterns and the EVs influence on the energy net. In other words, the test pilots were committed to a number of obligations during the test period, but at the same time they got a chance to test an EV without economic expenses (apart from the loading cost at home). In return, CLEVER gained experience and knowledge of test pilots' 'sayings and doings'. Thereby, the projects underlying conviction is emphasising that user experience and performance are highly significant for paving the way for a qualified sustainably transformation of the energy system.

As mentioned, the expected main challenge was related to the load management and charging processes. In order to level out peaks and increase the incentive to move consumption to low-consumption hours, the 18 test pilots participated in 'Project Dynamic Pricing' launched by the energy company SE. This further demo-project offered the test pilots dynamic tariffs[4] (price of the transportation of electricity in the grid) and variable hourly electricity pricing (Nord-pol's spot-electricity price). At the first meeting with the 18 test pilots from Sønderborg and Åbenraa, SE introduced three general recommendations in order "to save money and care for the environment" according to 'Project Dynamic Pricing': To move laundry activities (washing and drying) and dish washing to hours when the spot-electricity price and net tariffs are the lowest (during the night), charge electrical equipment – and not least to load EVs during the night. The purpose of 'Dynamic Pricing' was to test consumers' flexibility to move their consumption to hours with low electricity demand and high production of RES, and to increase awareness of electricity consumption in general. SE collected the quantitative data consisting of respectively hour-based recordings of the households' electricity consumption. SE's overall aim was to avoid peak loads by increasing the economic incentives and thereby changing the conventional consumption patterns.

The hourly price (excl. taxes) of the spot electricity can be found on a website[5]. The Dynamic Net tariffs were divided into four categories (6 hours each) through the day.

The 18 EV drivers, who participated in this extra demo-project, had their test period extended with 2 extra test-driving months (5 months in total). One of the main reasons behind the extension was that CLEVER wanted to take over the load management half-way (2 ½ month) into the project and thereby check whether the households preferred to load their EVs by

1. The project is supported by Danish Energy and Transport Authority and private foundations.

2. During 2012, CLEVER established more than 60 quick charge stations (ChaDeMo) nationwide in Denmark. At the same time, CLEVER's infrastructure consists of private intelligent charging modules and hundreds of semi-public normal charging points.

3. The test pilots had free and unlimited access to recharging their EVs on so-called quick-charge stations, which are established on the parking lots of the Danish supermarket 'Føtex', in the towns Sønderborg and Haderslev respectively (a quick-charge takes 20–30 min).

4. Today all consumers pay a fixed price on every kWh, which means that consumers do not gain any economic benefit from moving their consumption patterns to other hours during the day.

5. http://www.nordpoolspot.com/Market-data1/Elspot/Area-Prices/ALL1/Hourly/.

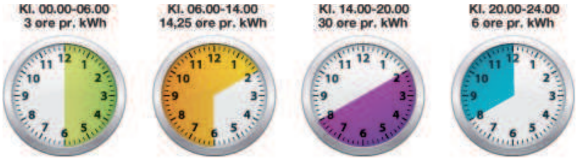


Figure 1. Dynamic Net tariffs for four divisions of the day in hours and prices. The figure illustrates the cheapest consumption hours from 00–06 am and that electricity is 10 times more costly in the peak-time hours from 2–8 pm. 0.04 Euro equals 1 Danish 'øre'. Prices are excl. taxes. SEs permanent net tariff for the spot electricity was 0.2 cent per kWh (February 2012).

themselves or preferred to let the load management be controlled by the mobility operator.

The empirical material

The empirical material was collected through qualitative interviews with 8 participants in the two demo-projects 'Test-an-EV" and "Project Dynamic Pricing". Furthermore, observations were made by participating in CLEVER information meetings and in meetings where the test pilots received and returned their EVs. Moreover, knowledge about the engagement and satisfaction of the test pilots and the success of the demonstration projects was gathered by means of surveys designed by CLEVER. Questions – initiated by this research – about routines, new habits and their persistence has been added in the surveys. Other empirical material consists of information, emails, documents and other 'writings' delivered and produced by the two demo-projects.

Selection of 'test pilots'

In order to extend the complexity and diversity of the empirical material, 8 households among the 18 households or in CLEVER's term 'test pilots' were selected who varied as much as possible regarding socio-economic background variables such as gender, age, education, income, civil state, household size, number of children living at home, daily driving distances, environmental and technological awareness (see Table 1). The assumption behind this is that more diversity contributes to a broader and fuller understanding of the complex nature of users' management and interaction with the technology.

The interview guides were inspired by the semi structured interview approach, characterised by being explorative and open for an in-depth dialogue about practice and everyday behaviour (Kvale 2006, Thagaard 2004). Hence, a trustful relation was sought to be established between the researcher and the test pilot. According to the inherent expectations of the two projects, to the test pilots' behaviour, we were particularly conscious of not representing the projects by clarifying the independence of CLEVER's agenda and thereby attempted to deconstruct expectations outlined in the two demo-projects. The interviewer stressed conversations on everyday life, rhythms, ordinary patterns, routines, conventional habits, temporal consumption patterns, development of new changes and routines – all issues were compared with the households' behaviour before and after obtaining EVs. The interviews were made at different times during the test period, respectively 1 ½ months into the projects and at the end of the test period. The reason for this was based on the idea that after 1 ½ months the households could clearly remember their everyday structure before obtaining the EV, but also on the assumption that routines and habits need time to develop. After the first data collection, it seemed easy for the households to remember their earlier everyday life, which is why we decided to make the last data collection as late as possible in the test period to ensure capturing as many changes as possible. All the interviews were transcribed and selected parts were translated (based on our interpretations) into English and analysed within the theoretical framework (presented later).

Despite the objective to reach complexity in the empirical material, there were several similarities between the 8 test pilots. Even though the reasons for participating were different, all of them were to a certain degree dedicated to testing the new technologies. In this regard, it has been argued that these 8 households were a non-representative group that consists of 'front-runners' or 'first-adaptors' who are particularly conscious, engaged and interested in EV technology (Brady 2010, Jansson 2009, Hippel 1988). Hence, this research argues that a representative case is not always the most appropriate strategy of achieving the greatest possible amount of information. By placing the research within the context being studied, insight in humans' social worlds, experience, behaviour and viewpoints is achieved (Flyvbjerg 2006:236). This case study was typified as 'a critical case' by acknowledging the following "If this is (not) valid for this case, then it applies to all (no) cases" (Flyvbjerg 2006:230). In this regard, it is assumed that if the technology had domestication difficulties among this sample of dedicated people, it seemed even more problematic to integrate it among 'ordinary' households which were less dedicated, engaged and informed.

The analytical approach

PRESENTATION OF SOCIAL PRACTICE THEORY

The Social Practice Theory has developed a series of concepts to capture the dynamic aspects of social practice in order to explain change, stability, novelty, persistence and social order in societies. These concepts are concerned with the understanding of how practices emerge, evolve and disappear in everyday life. Everyday life is where social practices arise, transform and fall and is thereby the ontological objectification of the social practice theory (Shove et al., 2012, Warde 2005, Schatzki 1996).

The philosopher Theodore Schatzki provided the notion of theories of practices[6] with fresh impetus through his recogni-

6. Notions of practice figures in different strands of social scientists e.g. Bourdieu, Giddens, Taylor, Foucault (Shove et al., 2012:6).

Table 1. Selection of test pilots to extend diversity on socio-economic parameters.

Test pilots	Gender	Age	Education	Annual income (in euro)	Civil state	House-holds Size	Children	Transportation need (km)	Environmental awareness	Technological awareness
Test pilot 1	F	61	Skilled*	60,000–101,000	Married	2	0	40–60	High	Medium
Test pilot 2	M	42	Skilled	31,000–60,000	Married	4	2 h*, 1 o*	20–40	Low	High
Test pilot 3	M	51	Unskilled	60,000–101,000	Married	3	1 h, 2 o	60–70	Medium	Medium
Test pilot 4	M	45	Skilled	31,000–60,000	Single	2	1 h	60–70	High	High
Test pilot 5	F	32	Skilled	31,000–60,000	Married	4	2 h	20–40	Medium	Medium
Test pilot 6	F	33	Skilled	31,000–60,000	Married	2	0	20–40	Low	Medium
Test pilot 7	F	48	Academic	101,000–134,000	Single	2	1 h, 3 o	0–20	Medium	Medium
Test pilot 8	M	36	Skilled	101,000–134,000	Married	4	2 h	40–60	High	High

** 'Skilled' stands for 3–4 years' education after finished high school diploma.*
** 'h' indicates the number of children living at home and *'o' indicates children no longer staying at home.*
Some of the categorisations are based directly on information from the applications of test pilots to CLEVER and some were unfolded during the interviews (e.g. 'Education' and 'Children'). The categorisations 'Environmental awareness' and 'Technological awareness' are our own assessments of the 'level' of the awareness of test pilots, respectively regarding energy use and concrete actions to decrease carbon emission and their technological skills. The ratings are therefore subjective definitions.

tion of practices as a routinised type of behaviour formatted by individuality and social order in an on-going process that continually challenge and transform habits and routines in the daily life (Schatzki 1996:13). By the recognition of the social life as situated in practice, Alan Warde considers conventions and standards of practices as steering the behaviour and acknowledge consumption as a "corollary of the way the practice is organised, rather than an outcome of personal choice, whether constrained or bounded" (Warde 2005:137).

What in particular distinguishes social practice theory from other (conventionally) social and cultural theories is the emphasis on involving material configurations in the social practices. Therefore, the social practice approaches have always recognised the role of things and the material dimension in the constitution of everyday life. (Schatzki et al., 2001:3, Warde 2005:137, Shove et al., 2012:9).

CONJUNCTION OF ELEMENTS (HOLDING A PRACTICE TOGETHER)

The social practice approach has developed a concept that captures the dynamic aspects of social practices like e.g. driving, cooking, washing, lighting, bathing, smoking by a means of systematically exploring processes of transformation and stability within social practices and between them (Shove et al., 2012). In this article, we use Gram-Hanssen's interpret of social practices conceptualised into the four elements: 'Know-how and embodied habits' (the way our body takes in things we learn and are socialised to do), 'Institutionalised knowledge and explicit rules' (explicit rules, principles, precepts and instructions), 'Engagements' (motivation and meanings according to doings) and 'Technologies' (technology design makes actions obvious) (Gram-Hanssen 2011b:65, 75). It is through connections between the four elements that stability and change in the social are conceptualised.

Two central notions within the practice-theory approach are the conceptualisation of 'Practice-as-entity' and Practice-as-performance' (Warde 2005:133). Practice-as-performance involves the active integration of the elements that are performed. It is through the active performance and the integration or so-called 'nexus' of elements, that the practice-as-entity is changed and reproduced. Practice-as-entity is the existing practice, conjunction of elements, which can be spoken about as a set of resources. As Warde states "Practices are thus coordinated entities but also require performance for their existence. A performance presupposes a practice" (Warde 2005:134).

The analytical distinction is useful for understanding how changes – novel combination of know-how and embodied habits, institutionalised knowledge and explicit rules, engagements and technologies – are enacted, performed and reproduced by the characteristics of the entity and how the new consumption patterns are sustained and at the same time developed by the practitioners performing the practices (Shove et al., 2012:8). Reproduction and change in practice is developed by practitioners' doings (individuals feature as the carriers of a practice) and their willingness to integrate and link the different elements. In this regard, practices change when new or existing elements are combined in a new way. At the same time, the elements are themselves outcomes of the practices. Warde states that the sources of changed behaviour are developed in the practices themselves, whereby the concept of practices has the capacity to account for both reproduction and innovation (Warde 2005:140). Discussing the implications of using social practice theory in consumer research, Warde assumes that consumption occurs within and for the sake of practices. Thus, he considers that a competent practitioner requires know-how and commitment in order to deliver an appropriate consumption of goods and services (Warde 2005:145).

Despite change and continuity being regarded as an outcome of the integration of elements, the theory suggests that researchers separate and detach the elements from the practices of which they are a part. At the same time, the analytical approach emphasises the need to be aware of "the trajectories of the elements, and to the making and breaking of links between them" (Shove et al., 2012:22). Moreover the theory states that all practices are internally differentiated so that persons in different situations do the same activity differently (Warde 2005:146). The analytical framework of this article is inscribed in the understanding of seeing social life as constituted by the concrete situational circumstances in local contexts (Clarke 2005).

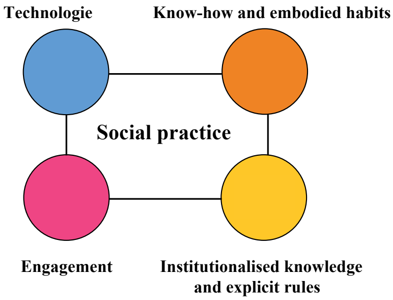


Figure 2. Four different elements holding a (e.g. driving) practice together (and the links between elements).

CONCEPTUALISATION OF THE EV(ERYDAY) LIFE

The conceptualisation of change and continuity in everyday life according to the theory of social practice is consistent with this paper's assumption that sustainable development, transformation and innovation have to become embedded in everyday life. According to the particular focus on smart-grid technologies, the socio-technical approach seems highly valuable in comprehending how social practices and technologies mutually shape each other in specific contexts (Gram-Hanssen 2011b:73, Warde 2005:140). Moreover, the framework underpins Adele Clarks 'Situational Analysis' acknowledging context-specific factors as essential in the constitution of the complexities in practitioners' social practices (Clarke 2005).

This paper focuses on the complex dynamics of social practices according to families living in the South-West of Denmark, who test-drive EVs every day in their everyday commuting. The qualitative approach focuses on the individual households' everyday life and how the 'practitioners' become carriers of particular new practices. Further questions on how routines and embodied habits constitute everyday life will be examined: How does change in one element/new 'material' influence the other elements, meanings and competences? What are the characteristics of the different elements and how are they integrated and linked? How do the new consumption patterns depend on the particular socio-economic conditions in the family? How can change in one practice affect other practices? How do new practices reflect the projects' institutionalised and explicit rules and to what extent will they persist? How do practices and bundles of complex practices relate to other practices – does driving an EV have spill-over effects e.g. do new consumption patterns develop? How are the practices held together in a whole range of practices and as a part of different practices?

Thus, the analytical framework mainly clarifies the trajectories of practice-as-entities by exploring the test pilots' everyday 'sayings', expressions and experience with the new technology. The 'doings' are only explored by proposing concrete questions about concrete habits, temporal actions and activities every day and during weekends. In other words, this article does not include the logged data on 'doings' (collected by CLEVER and SE). Despite the test pilots being convinced that their 'sayings' reflect their real 'doings', their perceptions are not necessary in accordance with 'reality'. A comparison of 'sayings' and 'doings' will be undertaken in later research.

Analysis of changes and continuity in EV drivers' everyday life

Based on the interviewed families' 'sayings', perceptions and comprehensions of (positive and negative aspects of) the smart-grid technologies effect on their daily patterns, the case study has identified the following two new overall social practices in everyday life: 'New driving performances' and 'new energy consumption patterns'. Based on the empirical material, the analytical sections present the two different, and at the same time integrated, social practices and how they influence the test pilots' everyday life. The conceptualisation of social practices is, more and less explicitly, added to the analysis of the two practices. Some of the elements are strongly integrated and overlap each other, which mean that the content of each element/division is a product of a continuing interpretation process. The analytical sections summarise some reflections on how the 'peak-shaving' technologies, each consisting of the four elements, influence everyday life, their persistence and how the two practices are linked.

NEW DRIVING PERFORMANCE

According to the test pilots' understanding , EV technology influences their 'way of driving' in three overall areas, which can be categorised as: 'more frequent driving', 'consciousness of driving distances' and 'increased awareness of other road users/traffic'. Following considerations on load-management practice and EV-driving as a social performance is examined.

Frequent driving

Almost all test pilots proclaimed that they used the EV more often compared with their conventional car. Some of the frequent interpretations were that the car mechanisms were interesting to try (particularly in order to challenge the battery capacity), that the mechanism/power engine was designed for short and impulsive trips and furthermore that it felt easier and cheaper to make a quick 'get-a-way' in the EV. Consequently, we suggest that the increased EV driving has a tendency to replace cycling and walking and that the test pilots' EV experience created a need for an extra car in the households. The following pronouncement indicated the motivation for an extra trip as a matter of 'testing', 'quick to ride' and 'cost efficient':

> Well, it happens that we take the EV for a little extra evening drive to get it out and test how far it can drive on the last battery power. The miles to the small trips, hang probably a little looser if you own an EV yourself, because it is cheaper to drive and you can easily just take a quick ride (…). As just said, we take an extra driving trip in the evenings e.g. to the beach eating an ice cream and then it is fun to see if we can make it on the last two 'points' [battery indicators]. (Female, 61 years.)

The following quotation exemplified consciousness about the power engine's capability and potential for shorter trips:

> I must say that for these short distances into town, well, then I take the electric car rather than walk as I did before. You don't think as much about saving the car engine, because you don't have the same wear on the electric car, as you have on the other. (…) in a diesel car you better drive some longer distances (…). (Male, 45 years.)

The increased driving means that the test pilots used the car for shopping and visiting and thereby decreased their mobility on bikes and by foot. As a young test driver declared: "We have driven quite a lot of extra trips, where we normally would have biked or walked for example to the shopping mall, then we now take the car every time (…) particular in the weekends." (Female, 33 years.) Additionally, a family father used the EV to do some extra trips every week, as he stated: "So I've taken the car a few extra times to pick up kids at the institutions, where I probably would have walked or biked before. We have surely taken a few more trips – it is like 'arrh, should I just take it?' and then 'Oops, then you are gone with the car quickly eh'." (Male, 36 years.) Overall, we suggest that this participant's response was closely related to the test element and the opportunity to use the new technology as much as possible during the test period.

EV driving increases the need for an extra car

All the interviewed households, who already owned one car before the test period, expected that the test driving would increase their need for a second car in the future. This finding seemed paradoxical in view of CLEVER's demand about not to increase car driving in the future. These expectations are not developed by testing the new technology but are rather an outcome of the advantages and e.g. the feeling of 'liberty and individuality/independence' experienced by having an extra car. One of the general and recurrent values was the feeling of 'liberty and individuality/independence' experienced during the test period. As one of the young women claimed, referring to the EV:

> I've suddenly got time just to be me and to do things I immediately want (…) for example I experienced the liberty of not being dependent on waiting for a colleague when I finished work or not to time my life according to the bus schedule (…) it's quite dangerous, because in a short time we have to return it [the EV] and then we need to have a car number two because we have become used to it (…) yeah, in my view it has actually been a little stupid to try, because it worked fine to get a ride with others or take the bus to work, so the car has created a luxury need (…) it is somehow easier to take the car and get your shopping done once in a week. (Female, 33 years.)

Moreover 'comfort and convenience' were benefits experienced by the users. "Suddenly you have two cars and then suddenly you have got a new need for having two cars (…) of course it is more convenient and nice to have two, we have developed a need that we didn't think we had, so to speak." (Male, 36 years.)

In this regard, the development of extra needs and the associated consumption seemed inconsistent with the EVs' expected potential to transform a sustainable energy system. In this context, it is important to quote that the test pilots did not have any expenses (except for electricity costs) related to testing the cars, which means that the need will continue being a desire rather than a realized cost and thus it is questionable that the test-driving actually will develop extra needs.

Huge consciousness of driving distances and consumption

Every test pilot expressed how the EV increase the awareness of driving distances due to the batteries' limited capacity (on average max 100 km per charge). Everyone was very conscious on the electricity consumption while driving and attempted to drive as 'economically' as possible. This led to more consciousness of driving distances and consumption of battery power: "Well I'm certainly more aware of where I actually drive and it has surprised me how much you actually drive. The EVs' battery capacity makes you incredible aware of hey you have again travelled 100 km. (…) well the air-conditioning is only on if it is really necessary." (Female, 61 years.)

The influence of the technology on driving practice was further portrayed in the following notions: "You do notice all the time, the amount of battery left on the dashboard and how many miles you have driven (…) in my view the hugest difference (compared with a conventional car) is that you think about how many miles you drive on one charge." (Male, 42 years.) And further: "The biggest change is the fact that we become more aware of to where and how far I supposed to go. This about calculating distances is something I haven't done before, not to the same extent at least." (Female, 32 years.)

> Furthermore, the limited driving distance of EVs led to a great deal of coordination and planning of conventional driving routines and moreover developed some new skills/competences and techniques. The businessman managed the limited battery capacity by coordinating the different appointments with customers and business partners in a tightly planned schedule instead of spreading them over the week, as he explained "Earlier I just randomly threw meetings in [in the calendar] and now I think 'where do you call from? From Åbenraa! Okay what else do I have to do in that area' (…) during the test period I've become much better to cluster my appointments in specific geographical places." (Male, 36 years.)

New driving techniques

The constant awareness of the limited power engine resulted in the participants developing new driving skills. The most frequent is to turn off electrical devices like radio and air-conditioning and to drive as economically as possible to improve the range of driving. A test pilot, who drove at least 70 km every day, supplied a detailed description of economic driving. The following is a selected excerpt from a long description:

> You drive economically by avoiding to decelerate [laughing] (…) it's really about not to press too hard on the accelerator and then keep a constant speed. By the way I really miss a cruise control in the car. On the road between Åbenraa and Sønderborg there are five roundabouts and then I have learned to slow down the car, so I can release the accelerator and thereby recharge the battery it shows how economically you are driving [referring to the dashboard]) it goes down and write charge (…) you could actually take the roundabout with 40/50 km/h and then you do not use so much power for acceleration. So it is actually possible to drive back and forth to Sønderborg without full stops. (Male, 45 years.)

The new driving techniques contain an element of competition about to beat 'your own driving record and to challenge your partner's and further to more conversation with your partner about 'driving distance, battery capacity' etc. As one test pilot said "The funniest part is the competition between me and my partner to see who can drive the longest on a loaded battery." (Female, 33 years.) Apparently, this 'competition and playing' aspect was linked to the test phenomenon and reflected somehow a kind of new element. The persistence of these activities would probably decrease during the test period. The following illustrates the test sensation and is probably an example of an activity that only happens once: "One day I tested how many miles I could get the engine to drive and we almost manage to drive the maximum 140 km., no extra electricity use was on and then we just cruised around until the battery alerted us." (Female, 32 years.)

Increased awareness of other road users (and spill-overs to conventional driving)

Due to the material components of EVs, the majority of the test pilots had become more alert to the world outside the car. One of the typical consequences of a noiseless and vibration-free engine is the risk of faster speed during driving, which led drivers to be more aware of the speedometer and the surroundings in general. The noiseless technology was portrayed as having negative and positive aspects. The negative aspects typically concerned the uncertainties related to pedestrians and bikers, who also orient themselves by sounds, as clarified in the following: "People don't hear and see you, so you can't for example just back out. Pedestrians don't have a chance, because it doesn't say anything, which means that you can sit there in a long time just waiting to come out. Bikers can't hear you and in general it feels insecure." (Female, 61 years.) Another test pilot explains: "You can't just toot when you park, then you will shock people (…) But in general you learn quickly to pay extra attention." (Female, 32 years.)

Besides the uncertainty linked to the silence, the sensitivity of the EVs to external forces was further emphasised as something that increased 'the feeling of insecurity'. "The other day when it rained and it was really windy and cold, I switched on the fan and turned a little bit up for the heat and then the power meter immediately began spinning (…) so do not travel 50 km from home in hard weather conditions, because then you will not arrive before sunshine and you've got the wind in the back." (Female, 61 years.) This problem will apparently intensify in the winter period.

At the same time, quite a few test pilots favoured the silence and associated the peace in the car with something 'relaxing' and 'mindful' and appreciated that they did not have to shout to each other to drown out the sound of the radio, which conventionally is turned on to minimise the noise from the car engine. Especially a mother to two small children 'embraced the soundlessness', as she said: "The soundlessness makes it simply totally relaxing to drive home. The head gets straight and it's incredible how it allows your brain to calm down. Then I must admit, when you have picked-up the two children and get them into the car, you suddenly get a noise level that kicks ass. But oh yes, those 10 minutes in the car in total peace, no talking, no yelling, no nothing. It is simply a relief." (Female, 32 years.) Quite a few test pilots found that the increased awareness of their driving and new techniques would spill over on their conventional driving, which was considered to be a positive consequence of the test period, as a test pilot declared: "It [new skills] will be transferred to my other car. You were aware of those savings tips in advance, but you didn't practice them for real. Instead you just refuel gasoline on and drive. You can drive much more economically and a lot of people could save huge amounts of gasoline by driving a little differently." (Male, 45 years.)

Load management

After 2 ½ months, CLEVER took over the individual load management and controlled the recharge process according to the lowest electricity price on the market. This transformation from private to central load management was received as a positive fact among all test pilots, especially motivated by the economic gain and convenience. In this regard, it seems important to mention that most of the test pilots (five) expressed having problems installing the timers and a few (two) had decided not to use the timer at all. The households that could not get the timer to work had informed CLEVER and as a result another couple had had a new load-box installed that worked correctly.

Hence, it seems difficult to judge whether the technology was incomplete or whether the test pilots did not have the competences to manage the load-box or simply not prioritised how to learn how to use it. Nevertheless, the consequence was that almost all test pilots plugged in the load-cable manually until the net tariff was low after 8 pm. The fact that the technology did not work or perhaps was too complicated hindered us in concluding that the interviewed households preferred to be as passive as possible by handing over the load management to the mobility operator. Exactly this issue – a comparison of individual versus centrally controlled load management – was paradoxically one of CLEVERs main objectives of this particular case.

Regarding to the problems related to the concrete technology, the test pilots were overall content with the introduction of load boxes in their homes. Even a few test pilots actually found the principle/concept about home load management to be convenient and expressed relief at not having to go to petrol stations: "It is convenient that you avoid running away to the petrol station and instead managing to charge by yourself. In my opinion it always has been a plague to refuel, it takes time to refuel especially when the gas station is not on the road." (Male, 43 years.) Besides the bug problem, all test pilots found that their individual option of charging their EV to be a great relief and considered that the plug-in practice to have a minor impact on the everyday life.

The reason why the load management had insignificantly influenced their everyday rhythms was presumably that the test pilots quickly got the technology integrated according to other routines. Typically, they linked the plugging-in practice to their habits connected with turning off lights in relation to their sleeping practice. In the following a test pilot points out how load management had become a routine in daily life: "It is a kind of reflex like locking the house before the night to plug in the cable in the car." (Male, 45 years.)

The test pilots in general expressed that the load management in itself had already become a kind of everyday routine. In spite of that, some test pilots considered the load practice as one of the biggest changes and 'something extra to remember'. These statements occurred in relation to EVs' extended level of planning and coordination, which was caused by both the limited operating range and the new load-management practice. The most obvious objections came from a 'partly single' mother (due to her husband's job as a sailor, she was alone with their two small children every second month): "Every day I consider whether it is necessary to load or whether I can wait until tomorrow (…) I am constantly aware of where to go during the week (…) this is a disincentive in daily life." (Female, 32 years.)

Furthermore, quite a few test pilots confirmed that the recharge infrastructure was too incomplete. One of the test pilots declared the time aspect to be one of the crucial turning points and did not consider the price element to be something essential to adopt: "The quick-chargers are way too slow (…). I am privileged that I have all the money that I need, so it is the time which is costly for me and I am not willing to spend time on that." (Female, 48 years.) For her, the load management decreased her 'flexibility and liberty', which for her seemed to be the most important values. This emphasised that the test pilots generally had an uncomplicated relation to load management. An explanation could be the test pilots' commitment and loyalty to the test project and its expected obligations to the participants.

Breaking conventions and norms

Although it seemed that the load management overall had a minor impact on the everyday life of households, all test pilots expressed concerns about the 'unstable' load box and the few times when the charge process had failed. Some test pilots expressed how these few stressful moments or breaks in their everyday morning routines led to a more permanent feeling of insecurity. In general, families with children have a tightly coordinated everyday life, which meant that the load management increased the level of planning:

> Well, it means I have to do things different than I'm used to and plan more. For instance the mornings are become much more uncertain because I have tried to experience that the car hasn't charged (…) It means that I sweat a little more. Such unexpected situations make me totally crazy, I fear the worst and the worst that can happen is for instance to run out of power (…) my day has such a tight time schedule, so three hours waiting for assistance simply destroy the rest of my day and tied planning. (Female, 32 years.)

One test pilot accidently experienced to run out of power on a longer driving distance. For her, this experience was completely unacceptable and limited her feeling of flexibility of lifestyle too much, as she proclaimed: "It is unacceptable that I should have to stop and charge on the way, I mean I've got this feeling of 'it is not okay, it is completely unacceptable, I simply do not permit that'." (Female, 48 years.) Presumably this dry-driving risk is related to EVs test-technology status.

Mainstream technology as a success criterion

The notions of the test pilots about positive and negative aspects of EVs were constantly compared with the mainstream conventional car technology. The positive elements reflected EV similarities to conventional cars (design and acceleration) and the negative objections surrounding EVs were the 'driving distance per recharge' and limited 'production costs', which were also the main critical issues addressed in the literature/state-of-the-art of EV adoption. (Sovacool and Hirsh 2008). In spite of this, all test pilots stated that EVs were a good city car and as such compatible with their daily needs. Its limited range challenged the adoption, which was typically connected with drivers' expectation of 'cars' symbolise values as freedom, independence, a necessity and the flexibility to visit family and friends spontaneously without planning etc. Accordingly, a frequent statement was that the limited driving range of the EVs required a conventional car for longer trips. With regard to the constant comparison, it seemed straightforward to proclaim EV users to be conservative consumers[7] by their constant comparison of the EVs with conventional cars, which was represented among producers (car manufacturers) expectations to absorb EVs by the mainstream technology. Although, the test pilots range design, commitment, advertising, costs differently etc. particularly uncertain factors like costs related to servicing and maintenance of the new technology seemed to dominate the test pilots concerns. Remarkably, no test pilots mentioned the economic fortunes related to EVs. Compared with conventional cars, the EVs are more than half as cheap in daily costs due to the much lower electricity price compared with fossil fuel prices.

A strong social performance of sustainable consumption behaviour

Environmental and green aspects were weighted highly and played a significant role for the test pilots' engagement. Consistent interpretations according to their participation as test pilots were 'a feeling of well-being and cleaner conscience', 'societal responsibility and contributing to curbing emissions' and 'positive feed-back from surroundings'. Therefore, it was a central question how consumers thought of themselves as sustainable consumers.

A feeling of doing something good for the environment and a feeling of less guilt characterise self-perceptions of the test pilots, as illustrated by the following expressions:

7. Sovacool and Hirsh argue that consumers instead of embracing new technologies seek tradition and familiarity when they make consumer choices, especially when they deal with hardware that requires high capital investment (Sovacool and Hirsh 2008).

> You do something it's like walking around with a Greenpeace batch on. There is a strong signal value in driving around in an electric car (…) I think it's nice to drive around without polluting, because some of the electricity comes from wind sources. And it gives me a really good feeling. And well, I'm sure the world would be much better if everyone drove around in an electric car. And I am also sure that in 20 years people drive around in electric cars. It is 100 % for sure. (Male, 45 years.)

Societal responsibility by contributing to curbing emissions seems a further motivating factor for participating:

> (…) the positive thing is of course that we do something extra for our society (…) we are all somehow responsible for taking care of the world for our children and children's children sake. (Female, 61 years.)

One test pilot even declared: "I am not so guilty about driving an extra tour because I do not think that I am doing anything wrong to the world." (Female, 33 years). A further view comes from a test pilot, who identified himself as 'environmental defender', who produced all his energy by PVs, which in his opinion made it even more meaningful to have an EV: "(…) and then the sun has recharged my car, then I can drive on my own system (…) I haven't burdened anything and this is a very nice feeling." (Male, 36 years.)

To a lesser or greater extent, all the test pilots were aware of their social performance as sustainable consumers. Some were explicit about their engagement in their considerations of EVs as a prestigious technology due to its strong environmental signal values. Consequently, the test pilots talked and socialised more when they went out shopping and visiting, for instance many of the EV drivers experienced positive feed-back from colleagues, family, curious strangers and other test pilots. All test pilots were proud of their EVs and regarded the increased socialisation (and to some extent promotion of the EV) as a completely positive thing. As one test pilot explained: "It has been an extra boost in everyday life to run in the electric car… to offer people a ride and a chit-chat. It has been a cool experience." (Male, 42 years.)

Promotion, answering questions and in particular to break people's expectation were highlighted as positive and motivating elements. As the enthusiastic businessman stressed: "You get a lot of contact with people when you drive around in this one (…) it is really nice, there are many who comes over and ask about it, and then you do a little advertising and talk positive about it." (…) I think the environmental appearance has been really good, both according to my personal but also to my company's image." (Male, 36 years.) Here, the EV-driving is an excellent way to brand his company's green profile.

EV driving conceptualised through the four elements

Even though EV technology shares similarities in many areas (particular design, comfort and acceleration) with conventional technology, the battery makes the engine more sensitive to external forces, limits the driving distance and demands load management. The test pilots' expressions about the EVs potential and barriers were constantly compared with the standards of conventional cars. Based on general understanding of EVs as easy to drive, quick, convenient, maintenance-free and an excellent city car, it seems that 'know-how and embodied knowledge' related to EV driving is broadly comparable with the 'know-how' related to conventional driving.

However, this picture becomes more complex by recognising a new 'way of driving' caused by the limited range and the sensitive, noise-less engine of the EVs. The new 'way of driving' is characterised by developing more economic/sustainable driving techniques and increased awareness of consumption during driving. Further, the test pilots developed a more careful style of driving, more frequent driving and the need of a second car. In other words, the material agency develops new know-how and embodied knowledge that transformed the driving style and made transportation needs and habits more visible. Furthermore, it was acknowledged how both improved awareness on energy consumption during driving and increased consciousness of external conditions could spill over on conventional car driving.

In general, the test pilots found activities connected with the load box and load management simple and uncomplicated. Nevertheless, several test pilots expressed frustrations problems connected to install the timer in the load boxes which required manual load management. Presumably, this factor explained the test pilots' satisfaction with letting CLEVER control/peak-shave the charging process. In this regard, we emphasise that the element of 'institutionalised knowledge and explicit rules' (learning, information and demands) delivered by CLEVER had a crucial impact on the driving and especially the load management during the night. Further, the element of engagement seemed to be crucial for the 'way of driving', especially according to the 'test pilots' self-perception as sustainable consumers. The test pilots perceived their participation as meaningful by contributing to curbing emissions and a 'greener' behaviour. All test pilots considered EVs to be prestigious and were proud to be driving around showing their new technology (and 'responsibility') to their surroundings. In this way, the test pilots insinuated that they got positive feed-back from their surroundings and that EV driving in general led to a good feeling of well-being and a clear conscience.

TIMING: NEW TEMPORAL CONSUMPTION PATTERNS

Project Dynamic Pricing had apparently moved the test pilots' everyday electricity consumption patterns. Every household attempted to move their 'flexible' electricity consumption to the night when the net tariffs and spot-electricity price were lowest. The 'flexibility' electricity consumption included dishwashing, laundering and drying, and obviously the charging of the EV. Thus, all test pilots loaded their EVs during the night and used timer mechanisms to postpone their laundry until nights when tariffs were lowest. The move of flexible consumption by all test pilots indicated that Project Dynamic Pricing's overall aim (at least in the experimental phase) was achieved.

In the following, we dispute that the engagement to move electricity consumption was driven by respectively 'an economic' and 'an institutional' incentive. Next, we emphasise that these new consumption patterns influence other practices and how the flexibility depends on contextual socio-economic conditions. Furthermore, the tendency to increased environmental consciousness is acknowledged. The different elements of the practice are then conceptualised.

Economic, environmental and institutional incentives

Every test pilot considered the electricity price and the 'money-saving factor' to be essential in order to increase the incentive to change consumption patterns. Presumably, the extra electricity consumption caused by the EV improved the economic incentive[8] to move the consumption patterns, as one test pilot declared: "If we didn't have a car (EV), the benefits of the Project Dynamic Pricing would have been incredibly low." (Male, 36 years.)

In general, the expectations to the up-coming electricity invoice were huge, though many of the test pilots realised that the amount of money actually saved was 'peanuts'[9] and emphasised that a permanent change demanded a bigger economic gain. More test pilots expressed that a graphic visualisation and some concrete calculations on the actual savings would increase their incentive. While every test pilot knew the four dynamic tariffs by heart, hardly any checked out the 'spot electricity' (changing every hour) claiming this activity as 'too time consuming and unnecessary'. Generally, concrete and simple communication about savings and prices appeared to be vital in the busy everyday life, as stated: "Well, it is a must that the price only changes four times a day." (Female, 32 years.)

The project rules, conceptualisation and requests to the test pilots influenced the test pilots' expectations and their level of participation and commitment. The test pilots had agreed to several requirements (signed a contract) out-lined by CLEVER in order to participate and every participant was aware of accommodating the expectations from both demo-projects. On the information meetings the project managers were encouraged by the following phrases: "the first projects ever integrating EVs and Dynamic Pricing", "that the future demands new consumption patterns", "EVs become first a realistic alternative when consumption patterns change", "test pilots are capable to save money and contribute to sustainability by moving their consumption" and that the overall project aim was to "test the test pilots flexibility".[10]

From this aspect, more than a few test pilots emphasised their motivations by preparing some good habits in order to meet the future energy scenario, as one test pilot mentioned: "I have been conscious about moving my energy consumption for a long time, because I know it will be the future. It is the future." (Female, 32 years.) Environmental aspects were not apparent as a separate issue according to changed consumption patterns.

Throughout the qualitative interviews, the test pilots referred frequently to the expectations from the demo-projects. In this regard, it seems relevant to highlight the probability that the test pilots' new consumption patterns were changed by their own expectations that to some extent at the same time were constructed by out-lined requirements (and discourses around and within) the two demo-projects. One test pilot was obviously not driven by economic incentives, but rather the forecasting expectations given by Project Dynamic Pricing: "I do not care about the prices, but the project declared through the low prices the great need to move consumption to the night and I thought I better do it too." (Female, 48 years.) From her point of view, also her and her daughters' low energy consumption meant that the actual savings were too small. The explicit and implicit expectations roughed out by CLEVER were asserted by another test pilot excusing his limited commitment by referring to his duties at the job: "I really wished to deliver but the high expectations (from CLEVER) I wasn't able to meet. I haven't applied what I supposed. They provided us with a car, I signed up and agreed to do different things and it is such a shame that I didn't fulfil all." (Male, 36 years.)

In addition, all test pilots find some of the conducts/duties related to participation disturbing and time-demanding. The worst element is the so-called driver's log book (the test pilots registered information about every single drive in the EV), but also the daily blogging on the 'test-an-EVs' homepage was considered to be a difficult, time-consuming obligation. Inconsistent with the project aim to commit participants through incorporation/implementation of several obligations etc. the test pilots actually considered those out-lined institutional expectations (and rules) as too (time-) consuming but not unreasonable.

Constitution of new routines

The new consumption patterns constitute the households' morning routines. A direct consequence of laundering and dishwashing during the night were the developing of some new routines concerning 'hanging up washing clothes' and 'emptying the dishwashers' in the mornings. The impacts of the new practices/domestication processes proceeded differently according to the social-economic conditions of families and had different implications for flexibility. For instance, the interviewed families' with 1–3 children and pets seem not as flexible as households consisting of singles or couples with no children or pets.

In the following, test pilots with families with 1–3 children are presented, who considered the 'new element to remember' to be a disturbing extra element that interrupted the morning routines and habits and was the overall cause that the already tightly scheduled mornings became more pressured and stressed, as a family father highlighted according to their new consumption patterns "to remember that and further to remember that and that, today one is hanging up the washing clothes while the other empty the dishwasher. We need to rub our nails a little more, we have to hurry up more, to take shorter showers and let our child find her clothes faster." (Male, 42 years.)

It seems like, singles and the older couples were often more flexible in their habits and electricity consumption and e.g. more willing to compromise on their comfort than families with (small) children or pets. But the picture was more complex; for instance the older couple explained that they were less willing to move consumption when their children and grand-

8. In comparison, SE's Project Dynamic Pricing testing flexibility on over 200 households without EVs shows hardly any change of consumption patterns, which SE interprets as evidence that the economic incentive is way too low.

9. One of the main challenges for making consumers more active is that today households' electricity consumption is paid according to the average expenses and includes considerable taxes and tariffs. Despite the liberalisation of the Danish Energy Market (in 2003), the competition effects are limited, because the high taxes and tariffs limit the economic savings (Konkurrence og Forbrugerstyrelsen 2011). Pressure from the market liberalisation and smart grid challenges these conditions, which are expected to change with the so-called 'wholesale' model to be implemented in 2014.

10. The expectations were announced on two information meetings with the test pilots initiated by SE and CLEVER.

children were visiting. Furthermore, the degree of flexibility was related to the kind of job, the range of income and family size.

Increased awareness of electricity consumption and environmental consciousness

Almost all test pilots suggested that their environmental consciousness had been increased by their participation in the two projects. The interviews and the surveys indicated that test pilots saw themselves and their family as a whole and as more sustainable consumers in the future. Though all 8 test pilots were aware of energy consumption before they participated, they expected their consciousness to increase further, which was clearly stated in the following expression: "I am sure that this last half year led to a lower energy use and that it has influenced our reflections of what we actual do and when. I am convinced that the EV is crucial for increasing the awareness of energy use." (Female, 61 years.) Furthermore, Project Dynamic Prices increased the test pilots' awareness of the crucial role of the consumers and their responsibility in relation to changing their daily consumption patterns.

In this case, the participation had spin-offs on other areas in everyday life. Some expressed that they were more aware of turning down unnecessary light, to pack the dishwasher more, to check the weather before washing in order to sun and air dry laundry, wait to start the dishwasher until it was full etc. As an older couple highlighted about the two projects "the greatest change is that no doubt we have become more consciousness of electricity use and consumption." (Female, 61 years.) Again, it is impossible to predict the persistence and anchor of this apparently greater energy consciousness.

The four elements' constitution of new temporal consumption patterns

All test pilots moved their flexible electricity consumption to the night time, which meant that laundering and dishwashing activities occurred on other hours during the day. The empirical examples of households' postponement of electricity consumption indicated that Project Dynamic Pricing mattered. In the above analysis, we demonstrated how engagement to a high degree appears to be due to the element of 'institutionalised knowledge and rules' that constructs respectively 'economical' and 'institutional' incentives to move consumption.

This article further demonstrates how new consumption patterns interrupted households' morning routines which further developed some new routines about 'hanging up laundry and 'emptying dishwashers' in the mornings. Moreover, the impacts of the domestication processes proceeded differently according to family structures. Socio-economic conditions like family-size, income, age etc. influenced on the individual degree of flexibility and incentive to move electricity consumption. Especially families with children had a tightly coordinated everyday life, which meant that they had less potential flexibility, which meant that the Dynamic Pricings was considered to be an extra interrupting element that increased planning and coordination and made an already stressful everyday life more uncertain. Although routines and habits challenged flexibility, it seems remarkable that the entire group of test pilots participating in the two projects (18 test pilots) moved all their flexible energy consumption to hours with low demand, especially in regard to the very low amount of money saved.

Conclusion

This article has presented how two peak-shaving technologies changed consumption practices by influencing the delimited driving practice and developing new consumption patterns in the everyday life of households. Through the households' 'sayings' about their performances, it was possible to clarify the significant elements in the two new practices-as-entities, i.e. the new driving performance and the new temporal consumptions patterns. This article demonstrates how changes in consumption practices started in the everyday life of households through innovation in the different elements. Change in for instance 'technology', 'engagement', 'institutionalised knowledge and explicit rules' and 'know-how and embodied habits' changed routines in the everyday life and create new normalities by new combination of elements in the practices. This research showed how changes in the elements 'technology' (EV) and 'institutional rules' (new electricity pricings) influence the 'engagement element' by increasing people's consciousness about their energy consumption which in turn influences individual electricity consumption.

Furthermore, the research found how social consumption practices were linked and how change in one practice influenced another. The new 'driving' and 'timing' were closely linked mainly by sharing the elements of 'engagement' and 'institutionalised knowledge and explicit rules', which influenced the test pilots' 'doings' by the test projects' experimental character. We emphasise that the experimental test element was essential for the test pilots' peak-shaving activities and their level of participation and commitment. In other words, the persistence of the new consumption patterns and the practitioners willing to keep them alive seem doubtful. It is assumed that the new consumption patterns will 'fizzle out' after the test period ended. Like in many other demo-projects, the commitment of the test pilots will presumably decrease in the long run. The experimental short-term integration of Dynamic Pricing and EVs explained the 'acceptance' of inconvenient elements (limited driving distance, decreased flexibility and the uncertain stressful elements). In this regard, we stress that the limited test period to some extent prevented the new habits and routines from being really embodied. Time-and-space-significant impact on (anchoring) social practices was crucial for the recognition of this approach to the context-specific situational factors as geography/place, socio-economic elements and the limited time-schedule of the demonstration projects. A significant insight was obtained into the complexity of flexibility according to context-specific factors. The technologies and non-human elements impact on conventions and norms (and breakings) differed according to the specific character of normality in the test families. The socio-economic conditions were significant to the kind of incentive and degree of inconvenience in order to integrate the technologies in the everyday life.

Moreover this paper recognises how (consumption) practices are highly integrated with other practices. The two new practices are for instance linked through the increased economic incentive to recharge EVs when the electricity price is low. Moreover, the investigation clarifies how the new load management is integrated into conventional everyday rhythms like for example the sleeping practice and the daily shopping. Moreover, we stress the close integration of elements by for instance the close link between the expectations and engagement of institutionalised rules. This article emphasises how participation changed the attitude and comprehension of energy use and consumption in other areas of everyday life. Hopefully, the increased consciousness of new habits and routines will affect everyday life in the long term.

References

Axsen & Kurani (In Press). “Interpersonal influence within car buyers’ social networks: Applying five perspectives to plug-in hybrid vehicle drivers”. Environment and Planning A, accepted November 2010.

Brady, J. (2010), “Electric Car Cultures: An ethnography of the everyday use of electric vehicles in the UK”. Durham, UK: Durham University.

Clarke, A. (2005), “Situational analysis: grounded theory after the postmodern turn”. Thousand Oaks, Calif.: Sage Publications.

Christensen, T., Gram-Hanssen, K. and Friis, F. (2013), “Households in the smart grid – existing knowledge and new approaches”. NCCR-anthology (under publishing process).

Darby, S. (2010), “Smart metering: what potential for householder engagement?”. Building research and information, 38: 5, 442–457.

Flyvbjerg, B. (2006),”Qualitative Inquiry: Five Misunderstandings About Case-Study Research”. Volume 12, nr. 2 p. 219–245. Sage Publications.

Giddens, A. (1984), “The Structuration of Society”. Published in the United States by the University of California Press.

Gram-Hanssen, K. (2013), “Households’ energy use – which is the more important: efficient technologies or user practices” (under publishing process).

Gram-Hanssen, K. (2011b), “Understanding change and continuity in residential energy consumption”. Journal of Consumer Culture: Sage Publication.

Von Hippel, E. (1988), “The Sources of Innovation”. Oxford University Press, Oxford.

Jansson, J. (2009), ”Car(ing) for our environment? Consumer eco-innovation adoption and curtailment behaviours: the case of the alternative fuel vehicle”. Umea School of Business, Sweden.

Kvale, S. (2006), ” Interview – En introduktion til det kvalitative forskningsinterview”. København: Hans Reitzels Forlag.

Nyborg S., & Røpke I. (2011), “Energy Impact of the smart home – conflicting visions”. EGEE 2011 summer study.

Schatzki, T. (1996), “Social Practices: A Wittgensteinian approach to human activity and the social”. Cambridge University Press.

Schatzki, T., Knorr Cetina, K. and von Savigny, E. (eds) (2001), “The Practice Turn in Contemporary Theory”. London: Routledge.

Shove E., Pantzar M., Watson P., (2012), “The Dynamic of Social Practice – Everyday life and how it changes”. SAGE Publications.

Thagaard, T. (2004), ”Systematik og indlevelse – en indføring i kvalitativ metode”. Akademisk forlag, Copenhagen.

Warde, A. (2005), “Consumption and Theories of Practice”. Journal of Consumer Culture 5(2): 131–153.

The challenge of time shifting energy demand practices: Insights from Denmark

Freja Friis
Danish Building Research Institute
Aalborg University
A. C. Meyers Vænge 15
2450 Copenhagen SV DENMARK

Toke Haunstrup Christensen
Danish Building Research Institute
Aalborg University
A. C. Meyers Vænge 15
2450 Copenhagen SV DENMARK

Abstract
There is widespread agreement that the decarbonisation objectives of the smart grid agenda involve a reworking of the relationship between electricity supply and demand. Demand-side management on a household level requires changes in the temporality of electricity-consuming practices in everyday life. One dominant approach to demand-side management is to influence the temporality of households' consumption patterns by providing economic incentives through variable electricity prices. This paper explores the temporal flexibility of Danish households' electricity consumption through their participation in two smart grid projects: One is offering households to test an electric vehicle during five months and another is offering static time-of-use pricing. Based on qualitative interviews and hourly-recorded electricity metering data with families living in single-family detached homes, the paper shows that the combined trial influenced the households to time shift consumption from high-tariff to low-tariff hours in relation to three consumption areas: dishwashing, laundering and charging of electric vehicles. The analysis goes beyond this apparent flexibility and explores how time shifting of energy demand challenges the temporality of households' routinised everyday practices. The study recommends that future smart grid interventions acknowledge the temporal complexity and dynamics of interwoven social practices and how this affects the potential for time shifting energy demand.

Keywords
Demand-side management, temporality of practices, flexibility in everyday life, collective rhythms, personal dispositions.

1. Introduction

The political target for a complete transition of the Danish energy system to renewable energy sources by 2050 raises the challenge of finding solutions on how to balance intermittent renewables (wind and solar power) with electricity consumption (Danish Government, 2011, 2013). Here, demand-side management (DSM) and time shifting of electricity consumption attract growing interest from policymakers, researchers as well as commercial utilities (Christensen et al., 2013, Nyborg and Røpke, 2013). Denmark has the highest investment rate per capita in Europe in smart grid R&D and demonstration (Joint Research Centre, 2014), and a key focus of the smart grid strategies of the Danish government and energy sector is to create flexible electricity consumption (Schick and Gad, 2015). The Danish focus on DSM solutions follows a general trend in Europe and other parts of the world in policies, research and demonstration projects promoting a new 'smart grid' based on renewable energy production (Joint Research Centre, 2014; Darby and McKenna, 2012). In this way, experiences from Danish demonstration projects, like those presented in this paper, also apply to other countries.

Our study explores household experiences with changing temporalities of everyday practices. Based on two smart grid trials, the 'Dynamic Network tariff' (DN) trial with static time-of-use pricing and the 'Test an EV' (TEV) trial with plug-in electric vehicles (EVs), the focus is on how these smart grid solutions influence the temporality of practices related to dishwashing, laundering and EV charging. These practices are, in addition to electric heating, in general assumed to be particular time-flexible areas of domestic electricity consumption (Darby, 2012, Powells et al., 2014, Danish Government, 2013). Common for these practices is that they are highly routinised and in most cases carried out on a weekly or even daily basis.

Several researchers warn against being too optimistic about the potential of time shifting households' electricity consumption by turning our attention to the temporal-spatial interconnectedness of practices and how collective temporalities structure everyday practices even at the household level (Shove and Walker, 2014, Walker, 2014; Nicholls and Strengers, 2015; Powells et al., 2014). Hence, by departing from the dominating behavioural and psychological approaches, which place individual action at the centre of social change and emphasise flexibility as a result of individual attitudes, behaviour and choice (Shove, 2010), this paper focuses on the temporality of social practices and thus centres habits and routines as the units of analysis (Southerton, 2012).

From a practice theoretical perspective, the consumption of energy (and resources in general) is an outcome of performing practices as this integrates the use of energy-consuming technologies. Thus, the time patterns of energy consumption are closely related to the temporal patterns of the daily practices of households (Røpke and Christensen, 2012; Southerton, 2012; Walker, 2014). Therefore, in order to examine the potential and limits of the DSM approach, a better understanding of households' temporal organisation of everyday practices and how DSM solutions interact with these is needed.

Researchers like Lutzenhiser and Shove (1999) and Sovacool (2014) point to a general need for more research based on social science disciplines and methods within the energy research field, which in general is dominated by the disciplines of science, engineering and economy. A similar critique has been raised in relation to the smart grid field, which is also criticised for being heavily based on technical and economic disciplines resulting in simplified understandings of the consumers and the user context (Hargreaves et al., 2015, Skjølsvold et al., 2015, Strengers, 2013, Verbong et al., 2013). Thus, Verbong et al. (2013) note that "[a]lthough users have become more central in smart grid projects, the focus in the smart grids community is … still mainly on technological issues and economic incentives" (Ibid.: 124). However, the recent years have seen a growing interest among social scientists in exploring the social implications of smart grid visions and developments (as recently demonstrated by a special issue of *Energy Research & Social Science* on smart grids and the social sciences, introduced by Skjølsvold et al., 2015).

Our paper addresses these research gaps in two ways: First, by contributing to the development of better understandings of how energy consumption is an integral part of and shaped by (networks of) everyday practices. Second, by adding new knowledge to the underexplored temporal implications of smart grid solutions by exploring how DSM interventions like EVs and static time-of-use pricing are integrated into everyday practices and temporalities of households. We 'zoom in' (Nicolini, 2012) on the new temporalities of practices in order to study how these are constrained by collective rhythms as well as schedules at the individual and household level. Our analysis combines qualitative interviews with quantitative consumption data (load profiles) of households participating in the TEV and DN trials. The load profiles give an indication of change and continuity over time in the daily profile of the households' electricity consumption, whereas the qualitative interviews provide us with detailed insights into the participants' everyday life.

In the following section, we present the theoretical approach of our analysis. Section 3 presents our case study and methods, while section 4 and 5 present the empirical findings (load profiles and qualitative interviews). Section 6 presents our analytical findings and section 7 our final conclusions.

2. Practices, everyday temporalities and energy consumption

2.1 Practices and everyday temporalities

Different approaches to understand the relationship between practices and the temporality of everyday life exist within the practice theory field. Southerton (2012) offers three conceptions of this relationship. The first is *time as a resource*, according to which practices compete for time. The second is *practices as configuring temporalities*, which denotes how "different practices produce their own temporal demands based upon the degree to which they require coordination (or synchronization) with other people or practices" (ibid.: 343). This concept reflects the understanding of practices as constituting our experience of time and everyday temporality, which Shove and Pantzar advocate (Shove, 2009, Pantzar and Shove, 2010). Shove (2009) uses the term practice-time profiles for the "embedded conventions of duration, sequence and timing associated with the competent performance of a practice" (ibid.: 24).

However, whereas Shove and Pantzar understand everyday temporality as constituted *by* practices, Southerton argues for a recursive relationship by introducing his third concept of *collective and personal temporal rhythms*; i.e. how shared and individual temporalities influence the performance of practices. Collective rhythms also include institutional rhythms such as school and working hours and opening hours of shops. We also apply a recursive understanding, as we believe this opens for a more nuanced analysis of how the performance of practices (including when, where and how practices are performed) is embedded within and shaped by the overall rhythms and 'timescapes' (Adam, 1998) of the everyday life.

In relation to this, Southerton's (2003, 2009) concepts of 'hot spots' and 'cold spots' appear to be important for understanding the integration of DSM solutions into the everyday life of families. Hot spots are predictable periods of the day that precede institutionally timed events like meals, work and school time. They are intense in the number of activities performed within limited time periods and often involve multi-tasking (Southerton, 2003). An example is the afternoon 'rush hours' of shopping, picking up children and preparing food. Cold spots represent the antithesis by being periods of low activity associated with "'quality time', 'potter time', 'chill time' and 'bonding time'" (ibid.: 19). They are relative long durations of time typically spent on meaningful social activities. Cold and hot spots are interrelated as hot spots are "practical arrangements that permit the generation of cold spots or blocks of time released from necessary tasks" and "attempts to gain control over the temporal rhythms of daily life" (ibid.: 19, 20). Thus, experiences of harriedness are generally associated with the loss of control over the temporal organisation of daily practices (e.g. due to unexpected events).

Southerton (2009) notes that greater flexibility of institutionally timed events weakens the collective temporal rhythms. Consequently, personal time strategies (e.g. doing things faster and detailed planning) increasingly supersede collective rhythms. In this context, harriedness often relates to “the tension between managing the few remaining fixed institutional events (e.g. school times) and ‘cramming’ activities into self-designated hot spots within one’s personal schedule in order to free up cold spots of togetherness at other times.” (ibid: 61). Interestingly, and also contrary to the general weakening of institutional timing, the introduction of time-of-use pricing schemes for electricity consumption introduces a new kind of institutional timing with the explicit intention of influencing the everyday temporality of individuals and households.

2.2 Dispositions, procedures and sequences

Habits and routines are central for understanding the potential for DSM in households. Southerton (2012) identifies three conceptually distinct, but interrelated, forms of everyday action related to routines and habits. The first, *dispositions*, follows Bourdieu’s concept of habitus and refers to the “propensity or tendency to act in a particular manner when suitable circumstances arise” (Bourdieu, 1984, as quoted by Southerton, 2012: 341). Dispositions are culturally derived and shared orientations to the performance of practices that reflect variations between social groups due to their different conditions of existence and collective practices. They are transferable and not necessarily tied to specific situations. The second form is *procedures*, which refers to actions that have been “previously learned and ready to hand, waiting to be drawn upon when appropriate circumstances present themselves” (Warde and Southerton, 2012: 22). This relates to the tacit knowledge and embodied skills associated with the performance of habits and routines and partly shaped by culturally shared conventions. Finally, the third form is *sequence of activities*, which relates to how habits and routines often involve a specific sequence and timing of activities orchestrated by institutional and material scripting (e.g. related to the use of technologies). Taken together, these concepts provide a framework that presents habits and routines as “dispositions to, and procedures and sequences of, practice performances” (Southerton, 2012: 342).

2.3 The timing of energy consumption

Energy consumption and practice performance often occur simultaneously (like when driving a car and preparing dinner), but for some practices the consumption and performance are displaced in time. This is typically the case for practices where some of the activities are delegated to technologies that during periods run independently of the practitioners’ direct bodily intervention (e.g. the washing machine and the tumble dryer in relation to doing the laundry). However, the delegation of activities to technologies still requires incidents of interactions between practitioner and technology (e.g. loading/unloading the washing machine). These incidents can be termed ‘coupling constraints’ (Hägerstrand, 1985) for the performance of these practices. The use of devices like timers and remote control can help relax temporal and spatial constraints.

The use of household appliances that semi-automate daily practices such as doing the laundry, dishwashing and vacuum-cleaning (robot vacuum cleaners) is related to convenience, which is a central concept of this paper. Convenience is “associated with the capacity to shift, juggle and reorder episodes and events” in time (Shove, 2003: 170). Thus, convenience relates to the degree of control over the temporal organisation of practices in daily life. However, Shove notices that convenience appliances also contribute to fractured timescapes through required moments of intervention (such as the coupling constraints described above).

The smart grid vision of balancing intermittent renewable electricity generation with electricity demand by means of DSM implies, in the case of households, time shifting in the performance of the household members’ electricity-consuming everyday practices. Designers of DSM solutions often talk about making the electricity consumption more ‘flexible’, but this term is misleading, as DSM essentially introduces a new coupling constraint (the intermittent electricity generation) in the temporal organisation of households' daily practices. Thus, seen from a household perspective, DSM rather creates inconvenience through reducing the flexibility of daily life.

2.4 Social and natural-social synchronisation

A final key concept for our analysis is synchronicity, which Walker (2014) has explored in relation to the relations between time, social practice and energy demand. Synchronicity is "concerned with the relationships between rhythms, how they are matched or free running, locked together or disconnected, synchronous or asynchronous" (ibid.:52). The synchronisation of practices has – on an aggregated level – an important influence on the overall time-pattern (load profile) of energy consumption.

Walker identifies two forms of synchronisation: *Social synchronisation* is, like Southerton's concept of collective rhythms, related to practices that are "happening together in time, within and across their dispersal over space" (ibid.: 52), for example meals or working time. Walker notes that particularly electricity consumption peaks relate closely to social synchronisation. Peak loads are a result of the synchronisation of specific energy-consuming practices (e.g. cooking) or the bundling of multiple interconnected practices across society, including industry, commerce and civil society.

The second form of synchronisation is *natural-social synchronisation*, which relates to the natural rhythms and how these connect with social rhythms. Modern (convenience) technologies like air conditioners, electric light and tumble dryers have partially decoupled social rhythms from natural rhythms of the sun and weather. In many ways, the smart grid and DSM visions aim to 'reinstall' a synchronicity between social practices and natural rhythms related to the production of renewable energy.

3. Case study and methods

3.1 Presentation of case study

The Danish electric mobility operator CLEVER's aim with the Test an EV (TEV) trial was to increase their knowledge about EV driving and load management by testing 198 EVs among 1578 Danish households. A small number of the test-drivers also participated in the Dynamic Network Tariff (DN) trial implemented by the commercial electricity company South Energy (SE). The DN trial used a static time-of-use (Darby and McKenna, 2012) price scheme, which operated with four network tariffs. For instance, the network tariff was ten times cheaper during the night hours 0-6[1] (0.4 euro cent/kWh) than in the peak hours 14-20 (4 euro cent/kWh). Together with the market electricity price and taxes, the total electricity price for Danish household customers is about 0.3 euro/kWh. Thus, the maximum variation in the network tariff represents about 15% of the total electricity price and hence represents a relatively weak price signal.

Besides DN, the participants also had a spot price agreement, which is a real-time pricing scheme (Darby and McKenna, 2012) following the hour-by-hour market price of electricity on the Nord Pool Spot market. The average market price was about 4-5 euro cent/kWh. All interviewed households found the real-time pricing scheme too complicated and time-consuming to follow, why this scheme did not affect the households' electricity consumption. Even though further analysis of the households' reaction to the real-time pricing might have provided interesting insights, we will not go further into this aspect, as the households' did not have much practical experiences with this scheme (and therefore did not have much to tell about it).

[1] In this paper, we use the 24-hour (0-23) notation, i.e. 0-11 equals 12 p.m. – 11 a.m. and 12-23 equals 12 a.m. – 11 p.m.

The DN and TEV trials both aimed to test the impact of economic incentives on households' flexibility to time shift their electricity consumption. The overall presumption was that the participants' incentive to consume electricity during the most affordable hours of the day would increase by participating in two smart grid trials at the same time. The DN ran from April to November 2012, while the combined DN and TEV trial ran from May to October 2012.

Further, the electric mobility operator wanted to test the difference between two ways of performing the EV battery charging; manual load management and automated load management controlled by the operator. The shift from manual to automated load management was implemented less than a week after being introduced to the trial participants at a mid-term meeting in September 2012.

Households with solar power (photovoltaics) installed already or planning to install during the DN trial were excluded from participating in the trial.

3.2 Qualitative interviews

The qualitative interviews are based on a semi-structured interview guide promoting an explorative, in-depth dialogue about the participants' practices and everyday life (Kvale 2006, Thagaard 2004). Inspired by Spradley (1979), the interview guide endeavours to get insights into the participants' specific doings and sayings, daily temporal rhythms, routines and new consumption patterns.

Instead of producing generalizable and representative results, the success criterion was to explore the complexity of integrating smart grid technologies in an everyday life context. Hence, the relatively small sample represents a contextual situation in a specific time and place (see e.g. Flyvbjerg's (2006) considerations about strategic case sampling).

The interviews were carried out in the participants' homes and lasted 1-2 hours each. The 18 participants who participated in both trials lived in detached houses located in two municipalities in Southern Jutland. Based on information about the participants' socio-economic background, collected and provided by the electric mobility operator, we selected eight households with the widest possible variation in relation to gender, age, education, annual income, marital status, household size, children and transportation need (see Table 1).

The sample is characterized by households living in detached houses in suburban areas of middle-sized cities situated in an economically declining region of Denmark. All houses had a garden and a garage. Hence, the findings are difficult to transfer to households living in city apartments. For instance, the participants in our study had the opportunity for hanging clothes to dry outside in their gardens and to charge EVs in their garages. Something that city dwellers do not have. Additionally, it is important to notice that the trials ran during the summer season, which affects (among other things) the possibilities for hanging clothes to dry outside.

Households	Gender	Age	Education	Annual income (in euro)	Marital status	House-hold size	Children	Daily transportation need (km)
Anne-Mette	F	61	Skilled*	60,000- 101,000	Married	2	0	40-60
Søren	M	42	Skilled	31,000- 60,000	Married	4	2 h**, 1 o	20-40
Ebbe	M	51	Unskilled	60,000- 101,000	Married	3	1 h, 2 o	60-70

Hans	M	45	Skilled	31,000- 60,000	Single	2	1 h	60-70
Mia	F	33	Skilled	31,000- 60,000	Married	2	0	20-40
Viola	F	32	Skilled	31,000 - 60,000	Married	4	2 h	20-40
Hannah	F	48	Academic	101,000- 134,000	Single	2	1 h, 3 o	0-20
Nicolas	M	36	Skilled	101,000- 134,000	Married	4	2 h	40-60

Table 1: Key data on the interviewed participants and their households

*: 'Skilled' stands for max '4 years' of education (short and medium-cycle education).

**: 'h' indicates the number of children living at home and 'o' indicates children no longer living at home.

3.3 Quantitative data

The statistical analysis of the load profiles of the households participating in TEV and DN is based on hourly-recorded metering data delivered by SE. As mentioned above, the combined trial ran from May to October 2012. July, August and October were excluded due to the summer and autumn holidays, which would complicate the analysis due to the marked differences in the daily temporality. Also, we excluded May because of start-up problems related to the beginning of the TEV trial. Thus, we focus only on the load profiles of June and September (comparing 2011, 2012 and 2013). The June and September profiles are analysed separately due to the different seasons (e.g. duration of daylight).

The DN trial included 184 customers (including 18 customers also participating in TEV). For the purpose of our statistical analysis, meter installations related to farms, second homes or customers within retail or education were excluded from the sample as they were assumed to have quite different load profiles compared with ordinary family homes. This reduced the sample size to 171. Furthermore, households with a negative annual consumption in 2013 (indicating that they had installed PVs after the end of the trial) were excluded as well as a few customers with insufficient data due to metering fails, which limited the final sample to 159 households. This sample was divided into three groups (Table 2).

Type (sub-sample)	Number	Share of sample (%)
Households participating in both DN + TEV	14	9%
Households participating in DN (with electric heating/heat pump)	31	19%
Households participating in DN (without electric heating/heat pump)	114	72%
Total	159	100%

Table 2: Three categories of households in DN sample

None of the households participating in both DN and TEV had electric heating/heat pumps or PVs.

The load profile for each meter installation (i.e. household) was first normalised in relation to the average hourly electricity consumption for the period (100% = average hourly load) for this meter. Following this, the average of the normalised load profiles was calculated for each of the three groups above.

4. Analysis of load profiles

In this section, we present and analyse the load profiles of the participants in DN. Due to our qualitative interviews with households participating also in TEV, the main focus is on the participants with an EV, although we begin with a general presentation of the 2011 load profiles of all DN participants. The aim of the analysis is to provide an insight into the aggregated consumption patterns and how they might shift before, during and after the trials.

4.1 The temporal patterns of electricity consumption

Figure 1 compares the load profiles of weekdays, Saturdays and Sundays in September 2011 (i.e. before the trial) for all households (n=159). The load profile for weekdays shows a distinct two-peak pattern with a morning peak between 6-9 and an evening peak between 17-19. The timing of the peaks indicates that, despite the general weakening of collective rhythms mentioned by Southerton, institutional rhythms associated with school and working hours still play a significant role for the timing of the aggregated electricity consumption. In addition, the fact that the evening peak is higher than the morning peak indicates that the early evening hours are characterised by a multiplicity of electricity-demanding practices taking place at the same time within the home; diner preparation in combination with other activities such as use of information and communication technologies for school work and entertainment.

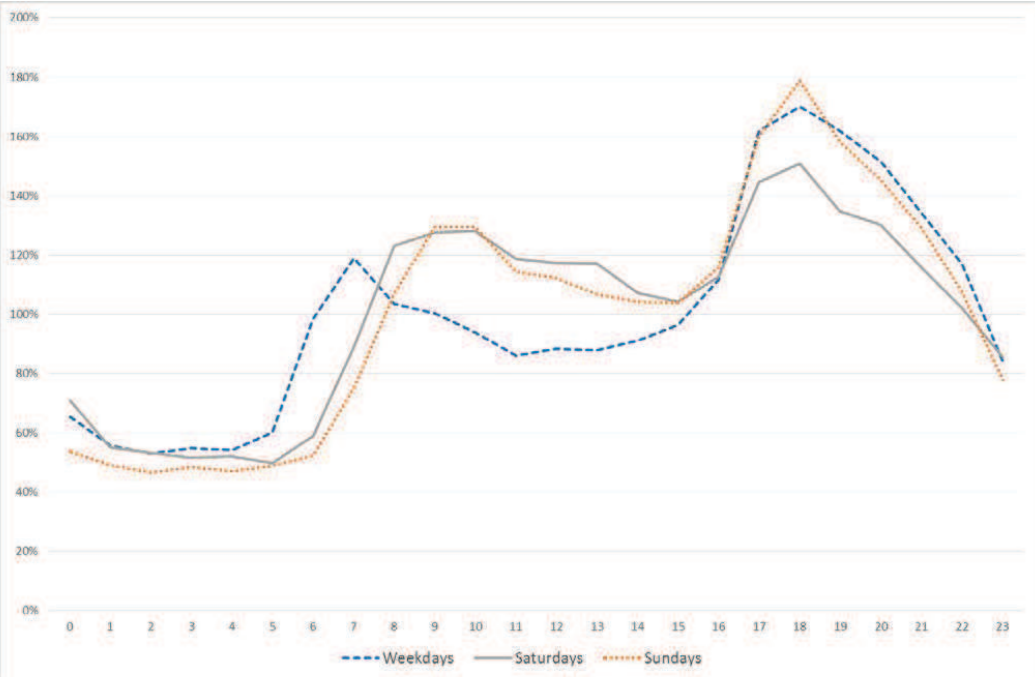


Figure 1: Load profiles (all households) for weekdays, Saturdays and Sundays in September 2011.
Hours shown on X-axis are in Danish Summer Time. 100% represents the average hourly load.

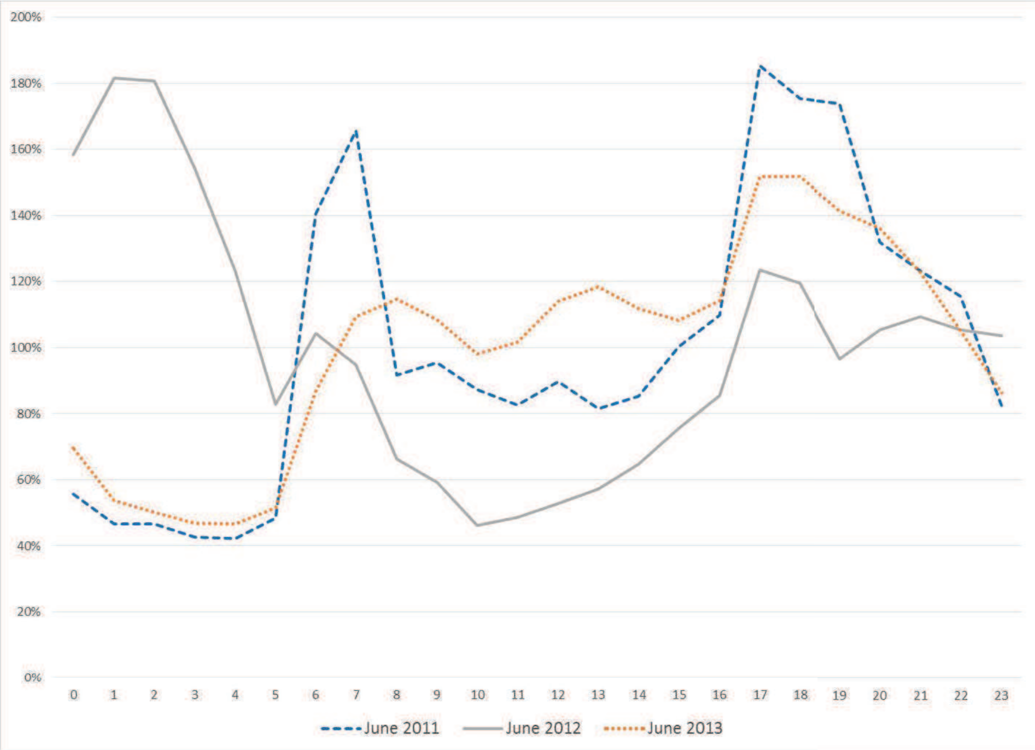
The morning peak on weekends is less distinct and occurs 2-3 hours later than on weekdays. This probably reflects that people get up later on weekends due to the lack of the institutional rhythms related to work and school. Interestingly, the evening peak occurs at the same time for all types of days, which indicates little variation in the timing of the evening meal preparation across the week. This suggests that the timing of the evening dinner is not only determined by institutional rhythms, but also by cultural conventions about when it is the ‘proper time to eat dinner’. Finally, the mid-day consumption on Saturdays and Sundays is relatively higher than on weekdays, which likely reflects that more people stay at home during the afternoon on weekends.

Compared to the aggregated Danish load profile (Christensen et al., 2013), the morning and evening peaks for the households in this study are more distinct (higher) than for the entire electricity network. However, this is to be expected as the electricity network includes also others sectors than households (e.g. industries) that do not follow the same time patterns as households.

4.2 Changes in the load profiles?

The metering data for the entire DN sample shows no significant differences between 2011 and 2013 with regard to the relative distribution of the electricity consumption on the time intervals used in DN (not shown here). Hence, the DN trial's long-term impact on the participants' consumption patterns was insignificant. Similarly, the differences between 2011 and 2012 for households without an EV are in general small, while the differences are considerably higher for households with an EV, which is to be expected as the EV introduces new and additional electricity consumption.

In terms of exploring possible long-term effects of the combined DN and TEV trials, a separate comparison of the 2011 and 2013 distributions of the electricity consumption on the time intervals used in the DN trial did not show any significant differences. However, a closer look at the changes in the load profiles of the households with an EV shows interesting variations over the three years (Figure 2).



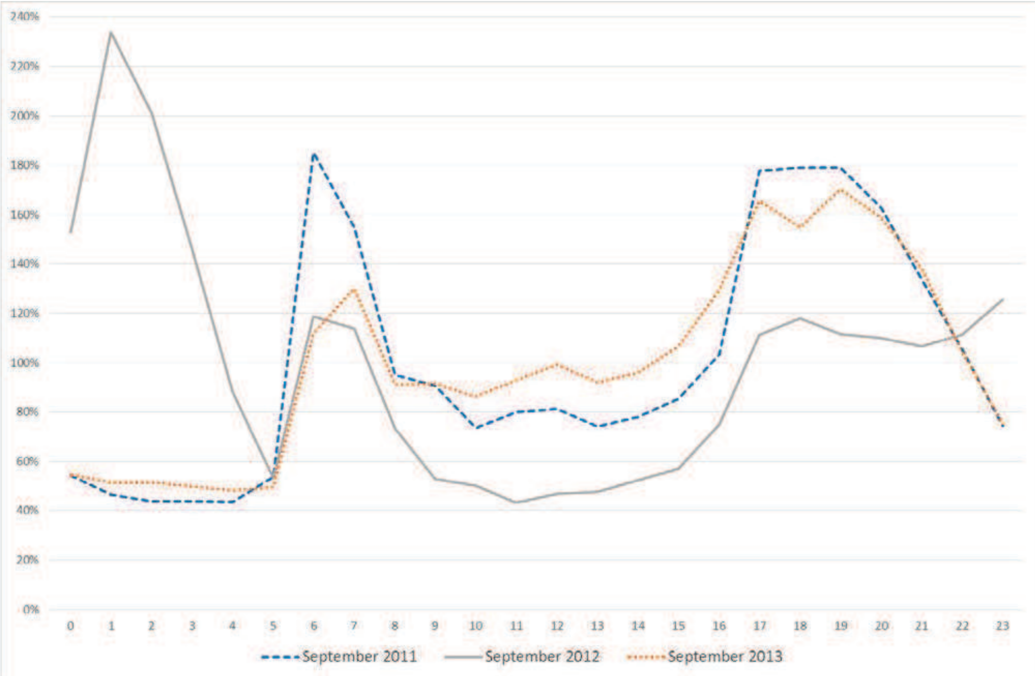


Figure 2: Load profiles of the households with an EV for 2011-2013 for weekdays in June and September.
Hours shown on X-axis are in Danish Summer Time. 100% represents the average hourly load.

As expected, the 2012 profiles show a night peak (related to the charging of the EVs), which is higher than the ordinary morning and evening peaks. More interestingly, the 2013 profiles have lower morning and evening peaks than in 2011, while the consumption during the day is higher. This is particularly evident for June 2013, while the September 2013 profile only differs for the morning peak. In absolute figures, the peak hour consumption is also reduced (Table 3). This indicates some degree of long-term time shifting in consumption from the morning and evening peaks to the late morning and afternoon hours for this group. However, due to the size of the sample (n = 14), it is impossible to make any robust conclusions.

	2011	2013	Difference
Morning peak (max kwh) – weekdays June	110 kWh	70 kWh	-35%
Evening peak (max kwh) – weekdays June	123 kWh	93 kWh	-24%
Morning peak (max kwh) – weekdays September	119 kWh	88 kWh	-26%
Evening peak (max kwh) – weekdays September	115 kWh	115 kWh	0%
Average daily electricity consumption per household (kWh/day) – Weekdays in June / September	5.2 / 5.0 kWh	5.2 / 5.8 kWh	+1% / +16%

Table 3: Size of morning and evening maximum on weekdays in June and September 2011 and 2013 (in kWh), difference in per cent and average daily electricity consumption per household. Households with an EV.

Regarding the other participants in DN, we only found a similar pattern with lower peaks and higher midday consumption for households with electric heating (not shown here).

5. Changes in everyday practices of dishwashing, laundering and EV battery charging

Particularly three areas of consumption came up recurrently in the interviewed participants' descriptions of their experiences with time shifting their electricity consumption: dishwashing, laundering and charging EV batteries. Therefore, our analysis focuses on these areas and in this section we briefly introduce the overall changes in the performance of the related practices, as described by the participants, before going into a more detailed analysis of the temporal implications of these changes in Section 6.

5.1 Dishwashing

All participants stressed that they usually manage to run their dishwashers in the low-tariff hours between 20 and 8, and thus avoid dishwashing during peak hours. Occasionally, the dishwashing during low-tariff hours was interrupted due to guest visits. The time shifting required unloading the dishwasher in the mornings, which for some households was a completely new habit to incorporate. This was generally considered as manageable, but also experienced as an extra doing and something extra to remember in the already tight-scheduled mornings. In particular, families with children found this inconvenient and stressful.

5.2 Laundering

Like dishwashing, almost all participants attempted to time shift laundry activities, but likewise experienced some challenges due to postponement. For instance, the economic incentive dwindled because some households did not use their tumble dryer due to problems with setting the timer, the disturbance caused by noise, and some did not own one. Like dishwashing, time shifting laundering also implied a new time constraint, which required new doings such as hanging the wet clothes to dry in the mornings in order to avoid that the clean laundry got smelly from lying in the washing machine for too long. Compared with dishwashing, this morning activity was considered as more inconvenient due to its greater impact on other routinised practices in the mornings, in particular as hanging the laundry to dry was performed in another place and away from the breakfast table. This disturbed the family togetherness over breakfast. Moreover, the new laundering practice changed the frequency of clothes washing as well as the organisation of laundry duties during the week resulting in almost daily laundering for some families.

5.3 EV charging

The participants easily adopted the new practice of recharging the EV batteries during the night hours (as also shown by the load profiles in Figure 2). They established a daily plug-in routine before bedtime that was only rarely broken by additional charging in the afternoon. As mentioned earlier, one of the main purposes of the combined trial was to explore the trial participants' flexibility and ability to charge their EVs during low-tariff hours. However, in the beginning of the trial, all interviewed participants experienced unforeseen problems related to the installation of the timers on their charge boxes, which forced them to plug in the cable manually. This manual plug-in practice was generally experienced as manageable, but also as something extra to do and remember. Therefore, the households preferred the automated load management that was introduced towards the end of the trial.

Summing up across the three areas, the above reflects the participants' high commitment to follow the trial scripts during the test period. Despite their efforts, all households also experienced time constraints related to changing the timing of their daily doings. Thus, the time shift of these three practices underlines the interdependence between practices, the semi-automated technologies and the temporal rhythms of the households' everyday life.

6. Analysis: Beyond the new temporality of practices

In this analysis, we demonstrate how change in the timing of electricity consumption challenges households' flexibility and notion of convenience by looking into the dynamics of the system of everyday practices. These insights suggest that smart grid interventions, aiming at 're-installing' the synchronicity between electricity demand and natural rhythms (intermittent renewables), should be aware of the pivotal mutual relationship between temporalities and social practices configured by collective temporal rhythms and personal dispositions and procedures. In the following, we first analyse how synchronisation is constituted by collective rhythms and, secondly, individual dispositions, embodied procedures and schedules.

6.1 Collective rhythms and synchronisation challenge flexibility of time shifting

Southerton (2012) defines hot spots as preceding institutionally time-fixed events such as work and school hours, which is comparable with Walker's concept of social synchronisation referring to the temporality of practices occurring at the same time across space (Walker, 2014). The three time shifting practices studied in this paper are semi-automated daily practices, which contain time constraints and require necessary interventions, particularly in the mornings, and hence coincide with the morning hot spot. Thus, the households generally experienced the extra doings and loss of control as stressful and inconvenient, particularly during weekdays.

As Southerton (2003) notes, harriedness occurs with the loss of control over the temporal organisation of everyday life, as this quotation illustrates: *"Sometimes it is a little annoying because it is like hey the clock is 6h, but I have to start the washing machine, vacuum-clean and also run the dishwasher and the tumble dryer, because I need clean clothes to wear. And I know that I could have scheduled and planned better to avoid this, but then I recognize that I am just not very good at doing this"* (Mia). The loss of control was experienced as particularly problematic the few times that the EV batteries were not charged in the mornings (due to a bug in the charging boxes). As a single mother notices: *"What makes me crazy is in the situations where the EV has not been charged and I know that I have a meeting to catch at work. That I find stressful"* (Viola). Hence, such uncontrollable happenings were considered as extremely stressful and unacceptable as they had a significant impact on the households' tightly planned synchronisation of collectively timed events with personal and family schedules.

Recent research by Nicholls and Strengers (2015) emphasises that households with children are less flexible to incorporate time shifting in their weekday routines and in particular require a sense of 'normality' through predictable routines in their everyday life. This seems closely related to the intensity of activities and 'doings' that is often high for families with small children and which affects the time flexibility of their everyday life. In correspondence with this, a representative time diary study of Danish households' time use confirms that households with small children (under 7 years) on average use 7½ hours per day on housework activities (including childcare), while couples under 45 years and without children use 4½ hours per day. This indicates that housework activities and time pressure vary with the age of both children and parents (Bonke, 2002).

Even though hot spots are tightly scheduled and crammed with activities, the households in the combined DN and TEV trial also describe the mornings as important qualitative time due to the 'togetherness' of the family before they separate to go about their individual activities (work, school etc.). The social togetherness around the breakfast table is a highly valued activity, which suits well with the concept of cold spots. Thus, cold spots can be embedded within hot spots, which blur the distinction between hot and cold spots as distinctly different temporalities of everyday life. It also illustrates that cold spots can be of short duration and not always lasting for a longer duration, as Southerton (2003) describes it. Thus, the introduction of new doings due to time shifting of practices challenges the performance of 'breakfasting' and its associated meaning of togetherness: *"Before, we were united here in the kitchen, now it is more like one is outside hanging laundry, while another is inside unloading the dishwasher. We have to hurry up a little extra"* (Søren). This shows how togetherness and caring are tightly constrained within an everyday temporality that is structured by institutional rhythms such as school and work hours.

Surprisingly, and differing from Nicholls and Strengers' (2015) findings, we found no connection between degree of time shifting and household size. Actually, the families with small children were those who most intensively managed to time shift their electricity demand. As a single mother explained about the need for extra planning: *"Nope, it is not a problem. I am used to hard-core scheduling of every single moment of my everyday life to get all ends to meet with two children"* (Viola). This indicates that the already harried mornings are flexible to change and reschedule due to an already high level of detailed coordination and planning. We will later show how time shifting depends on the family members' disposition with regard to reschedule their activities.

Another single mother retrospectively reflect on whether her flexibility to time shift would have been higher at the time when she lived together with her husband and three children: *"My incentive would probably have been higher when I had all my children living at home and my husband and dog, in those days where the activity level was high all day long. Or, um, on the other hand the challenge to time shift would probably be harder, but simultaneously the savings much higher (…) maybe it is just imagination, and in real life it would have been way too inconvenient"* (Hannah). In other words, busy families with children rely heavily on planning, coordination and multi-tasking in juggling the bundles and complexes of individual and shared everyday practices. With the understanding of cold spots as 'sacred' moments of togetherness, new doings are experienced as disruptive.

Following Southertons' concept of sequence of activities (Southerton, 2012), the following quotation illustrates how a family morning consists of a specific sequence and timing of habits and routines that are sensitive to new routines: *"(…) we have … to get up a little earlier or take a shorter shower. And Signe* [the daughter] *has to find her clothes quicker. In the beginning we consequently finished our mornings too fast, which meant that we were actually ready to leave before time"* (Søren). Unloading the dishwasher and hanging up the laundry in the morning challenged the whole sequence and synchronisation of practices. Due to the range of practices bundled and synchronised in fixed temporal schedules, interruption or change in one practice influence the timing of other practices and the entire bundling of practices – and vice versa. This shows how practices are performed in tandem with other practices (Nicholls and Strengers, 2015).

Another example of sequence of activities is the attempt to bundle the EV plug-in practice with other daily routines. Most households synchronised their plug-in practice with the existing 'shut-up-the-house-before-going-to-bed' practice, as a single father explains: *"it is a routine (…) it's like a reflex action which occurs in accordance with locking down the house before going to bed, well then I go out and plug in the cable"* (Hans). Hence, the plug-in practice is bundled with other daily routines (locking the house) and thus fits well into the already existing, embodied sequence of practices, which probably explains why the manual load management was easily routinised and integrated in the everyday life.

Powells et al. (2014) show that some practices are more susceptible to time shifting interventions (e.g. laundry and dishwashing) in opposition to others (like cooking and dining). Likewise, our empirical material underlines how some practices (and sequences of practices) are more flexible to change than others, as demonstrated by this quotation: *"I can't turn on the light during the night while I am sleeping; I mean, why should I do that? And my refrigerator and freezer use electricity all day long. I mean of course I could ask my wife only to watch television from midnight, but that would be a bit boring, nah? The only areas I actually can postpone to the night are laundry activities. I can't move the cooking and the coffee that are necessary in the morning. Well, dishwashing and laundering are what private households are able to postpone, but that's it"* (Nicolas).

In response to the smart grid vision of increased natural-social synchronisation between energy consumption and energy supply, the interviewed households had become more aware of the weather conditions during the trial. Several voiced their doubt about whether they would dry clothes outside during the winter season, as a father noted: *"Well, probably the incentive decreases to hang laundry to dry during the autumn and wintertime. But here in the summertime it is not a problem"* (Ebbe). Some participants even scheduled their laundry practices according to the weather forecasting, as a woman said: *"And then we attempt to wash at the right moments, but often it turns out that today the sun is shining, then we better wash our laundry so we can hang it outside and thereby save the tumble dryer"* (Mia). Again, this illustrates how weather conditions constitute laundering practices, but it also demonstrates the significance of individual circumstances. In this case, the flexibility of rescheduling laundering practices reflects that this participant was out of work (and therefore not restricted by working hours). Thus, the flexibility to wash during the weekday is linked to the possibility of taking in the laundry (before raining), which obviously is not possible for the majority of employed people. In general, the unpredictable weather represents a source of inconvenience.

Natural-social synchronisation is also revealed in several participants' expressed unwillingness to go outside in winter (due to the cold weather) to plug in the charging cable before going to bed. In addition, this indicates that the time of the trials (May-October) may have had some influence on the participants' degree of flexibility to time shift.

6.2 Dispositions increase the complexity of time shifting

The households' flexibility to time shift varies with their socio-economic background and personal scheduling, temporal rhythms and commitments; i.e. individual (and shared) dispositions and procedures of the household members. Although the participants generally assumed that stronger economic incentives would increase their motivation to time shift practices, the individual freedom to decide and reschedule is pivotal, as a single mother underlines: *"I do it because it fits in well with my established routines. Well, I wouldn't run the dishwasher and washing machine if it was a source of irritation. No matter the price or the sustainable potential from a society perspective, I wouldn't have changed if I didn't like to hang laundry to dry in the morning. Actually I think it is nice and convenient to do and it fits in naturally"* (Hannah). In this regard, the time shift was considered as easy to integrate because of her already established morning routines, i.e. her personal procedures and sequencing of morning activities.

The load profiles (Figure 1) show a more even two-peak pattern on weekends (in particular on Saturdays), which indicates that households in general have more flexible time schedules during weekends. This corresponds with the interviewed households' perceptions and did also affect their experience of degree of flexibility with regard to time shift consumption. A middle-aged single father explains: *"I attempt to charge the EVs in the night, and particularly during weekends I also programmed the timer of the washing* *machine to finish the program in the morning. But this is not possible for me to do on weekdays, because then I have to wake up a half hour before to hang the laundry to dry, so it is only during weekends I do that"* (Hans). Hence, the new time constraints are accepted as long as the decision is considered as personal and fits in with the existing rhythms of the everyday life. In this way, it also relates closely to the concept of convenience understood as the degree of (individual) control over the temporal organisation of daily practices. An elderly woman further emphasises the need to sometimes 'overrule' the scripts of the trial: *"Of course, we can't wait to start the dishwasher the days we are hosting guests, nah? Like the other day, when we were hosting children on holiday, three heads, then we ran the dishwasher outside the low-tariff hours, but usually all washing takes place after midnight"* (Anne-Mette).

More generally, convenience is a key theme in relation to the households' experiences with time shifting. On one hand, the use of technologies like the washing machine, tumble dryer, dishwasher and timers semi-automate sequences of the associated practices (laundering and dishwashing) and in this way relax the temporal and spatial constraints. On the other hand, the participants find time shifting too time consuming, which relates to Southerton's (2009) concept of time as a resource. This seems also to be among the main reasons why the real-time pricing was considered irrelevant by all; it would imply developing and adopting a new time-consuming practice of day-to-day planning and coordination. In comparison, the static time-of-use pricing (DN) was experienced as much easier to learn and incorporate in the daily practices and temporality of the household.

The perception of time as a limited resource was common among the participants. The extra time use connected with, e.g., extra planning and coordination demonstrates how practices compete for time: "*It is the time which is valuable for me, because I am privileged to have the money I need. Therefore I am not willing to sacrifice my time and compromise convenience"* (Hannah, 48). Similarly, a father was very enthusiastic about framing his everyday life as tightly scheduled, and explicitly stated his competences to schedule activities on an hourly basis. In his view, time shifting was excessively time-consuming: *"DN has not influenced my daily life. Not at all. Honestly, I have not put my mind to checking the prices (...). I know it is something about some tariffs going up and down, and something to save. And I think it is fine, but I can't spend my time on such things. Fine to charge during the night, but I know nothing about the savings. And if I need the car I need the car, and if it needs to be charged, then I charge it"* (Nicolas).

These quotations also indicate how the participants' dispositions, i.e. culturally derived and social group-specific orientations to the performance of practices, shape their reactions and commitment to the trials. Hannah, in particular, conveys an understanding where time saving trumps money saving. In this way, she seems to represent a (economic) position characterised by affluence and where economic capital can be exchanged for time, which shapes her personal orientation to the idea of time shifting her electricity-consuming practices. In contrast to Hannah's and Nicolas' self-representations as being time-sensitive and busy individuals (both having high incomes; Table 1), other participants put more emphasis on the money saving potential of participating in the DN trial. One example is the single mother Viola: *"Yes, I hope to save money every time I move my consumption. So that is certainly the reason why I move my consumption. It is the consciousness about 'now I save some money', switch on, so it is a matter of save energy or I mean save your wallet (…) All the time I am aware of how to optimise the money we got"* (Viola, 32).

This illustrates how the flexibility to change the temporality of practices also depends on socio-economic background and related dispositions (Warde and Southerton, 2012). Following Nicholls and Strengers (2015), this also illustrates how time shifting has inequitable financial and social impacts for different households, and that the degree of flexibility depends on who is required to perform them.

7. Conclusion

The households in the two smart grid trials managed to time shift their electricity consumption practices related to dishwashing, laundering and EV charging. Especially charging the EV during night (when the price was low) made good sense to all (resulting in a new night peak in the load profiles), and the households generally expressed that the trials had increased their awareness of the timing of their electricity consuming activities.

One important finding of the study is that combining two smart grid interventions (EVs and static time-of-use pricing) seem to increase the participants' active participation in time shifting their consumption. This suggests that future DSM strategies could benefit from combining interventions.

Even though several households expected that they would continue their time shifting also after the end of the five months trial, the analysis of the load profiles before and after the trial was inconclusive. No significant change was found with regard to the distribution of the electricity consumption by the time intervals used in the DN trial. However, the load profiles indicated some time shifting, which suggests that some long-term changes had taken place.

The analysis of the temporal implications of time shifting laundering, dishwashing and EV charging shows how the new time constraints introduced with the static time-of-use pricing complicated the performances of everyday practices and challenged the experience of convenience by increasing the feeling of harriedness due to extra doings and more things to remember and plan. This was in particular the case on weekday mornings, which illustrates how the temporality of everyday life is difficult to change. This is not only about cramming more activities into a moment of the day, which is already a hot spot in many families, but also about how new activities fit into the existing temporalities of the morning hours. For most of the families, activities like hanging clothes to dry in the morning challenge cherished qualities like being together around the breakfast table (a cold spot). This shows the need of future DSM strategies to be aware of how everyday temporalities shape (the experience of) of practices.

The analysis also shows how change in some sequences of practice can be facilitated through synchronisation with existing routines. Thus, the plug-in practice (EV charging) was coupled with the shut-down-the-house routine before going to sleep. The ability to bundle new activities with existing daily routines makes it easier for households to time shift their daily practices. In addition, new practices involving multi-tasking can be facilitated if these can be performed within the same space; like in the case of unloading the dishwasher while at the same time being together with the other family members in the kitchen area.

Collective rhythms have an important influence on the flexibility of daily practices. Some daily practices (like preparing dinner and showering) are so closely related to institutional rhythms like work and school hours that they are not even considered as subject to time shifting by the participants. Others are less heavily determined by collective rhythms and are therefore more open for time shifting. Dishwashing, laundering and EV charging appear to belong to this group, which also relates to the use of technologies that semi-automate the activities related to these practices. The timing of the electricity consumption and the bodily involvement in practices are partly decoupled. Further, the empirical material shows that the participation has increased the households' general awareness of natural rhythms, in particular those related to the weather conditions.

While collective rhythms play an important role in limiting the flexibility of time shifting, also the dispositions and existing procedures of the household members shape their orientation to and active participation in time shifting. The capacity and willingness to reschedule practices thus vary among the interviewed households. Some households are motivated by economic incentives, while others favour time saving and flexibility higher than saving money. These different dispositions influence their activities with regard to time shifting. This highlights the importance of designing DSM interventions to accommodate households' different dispositions.

Our analysis illustrates the close association between experiences of harriedness and the loss of control over the temporal organisation of the daily practices. This aspect applies to the participants' stories about how unexpected incidents (like failure of the EV-battery recharging) create great disturbance to tight schedules and therefore spur stress and frustration. Experiences of this sort can have a great impact on whether – and how – households integrate smart grid solutions into their everyday life.

A final observation relates to the very different receptions of the two different pricing schemes offered to the households. It is evident that the real-time pricing did not have any impact on the interviewed households. To follow the real-time prices was perceived as too time demanding as this would require developing an entirely new practice of consulting day-to-day price information and continuous planning of daily practices. This indicates that an advantage of static time-of-use pricing (compared with real-time pricing) is the simplicity of this solution *and* the possibility to develop new daily habits and routines, like washing the clothes during the night, which can be incorporated into the temporality of everyday life. Similar advantages might be related to some of the other DSM options identified by Darby & McKenna (2012), such as critical day pricing, critical peak pricing or peak time rebates, which could be followed up by future studies.

In order to support synchronization between electricity production and consumption (DSM), smart grid solutions need to observe the complex relations between practices within households and focus on the role of collective temporal rhythms as well as personal dispositions and temporalities related to households. Rather than simply focusing on changing actions of individuals, the smart grid initiatives need to recognise the temporal complexity of practices in order to create new sustainable organisations of consumption based on reliable and simple solutions that increase engagement and simultaneously not increase time pressure and inconvenience.

Acknowledgements

This article is based on research carried out in the Integrating Households in the Smart Grid (IHSMAG) project funded by the ERA-Net 2nd Smart Grid Joint Call. We would like to thank SE for providing the quantitative data for the load profile analysis. Also, thanks to CLEVER for providing access to the participants and other information related to the Test an EV trial. Finally, we thanks the editor and our anonymous reviewers for their valuable comments.

8. References

B. Adam, Timescapes of Modernity: The Environment and Invisible Hazards, Routledge, London, 1998.
J. Bonke, Tid og velfærd, The Danish National Centre for Social Research, København (2002).

P. Bourdieu, Distinction: A Social Critique of the Judgement of Taste, Harvard College and Routledge, London, 1984.
T. H. Christensen, A. Ascarza, W. Throndsen, K. Gram-Hanssen, F. Friis, The role of households in the smart grid: A comparative study, ECEEE 2013 Summer Study, - rethink.
Renew. Restart Dyn. Consum. (2013), pp. 2285–2296
Danish Government - The Danish climate policy plan: Towards a low carbon society. Copenhagen: The Danish Government. Download: http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/danishclimatepolicyplan_uk.pdf (accessed 2015-07-31), (2013).
Danish Government - Our future energy. Copenhagen: The Danish Government. Download: http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/our_future_energy.pdf (accessed 2015-07-31), (2011).
S. Darby, E. McKenna, Social implications of residential demand response in cool temperate Climates, Energy Policy 49 (2012) pp.759-769. DOI 10.1016/j.enpol.2012.07.026
B. Flyvbjerg, Qualitative Inquiry: Five Misunderstandings About Case-Study Research, SAGE Publications, Volume 12, nr. 2 (2006) pp. 219-245.
N. Hargreaves, J. Chilvers, T. Hargreaves, What's the meaning of "smart"? A study of smart grids. Norwich, Norfolk, UK: 3S Research Group, University of East Anglia, 2015.
Joint Research Centre: Smart Grid Projects Outlook 2014, Publications Office of the European Union, Luxembourg, 2014. http://ses.jrc.ec.europa.eu/smart-grids-observatory (retrieved February 2, 2016)
T. Hägerstrand, Time-Geography: Focus on the Corporeality of Man, Society, and Environment. The Science and Praxis of Complexity, The United Nations University, Tokyo, 1985.
S. Kvale, InterViews: An Introduction to Qualitative Research Interviewing, SAGE, London, 1996.
L. Lutzenhiser, E. Shove, Contracting knowledge: the organizational limits to interdisciplinary energy efficiency research and development in the US and the UK, Energy Policy, 27(4) (1999) pp. 217-227. DOI 10.1016/S0301-4215(99)00012-9
L. Nicholls, Y. Strengers, Changing Demand: Flexibility of Energy Practices in Households with Children - Final Report, Centre for Urban Research RMIT University, Melbourne, 2015.
L. Nicholls, Y. Strengers, Peak demand and the 'family peak' period in Australia: Understanding practice (in)flexibility in households with children, Energy Research & Social Science 9 (2015) pp. 116-124. DOI 10.1016/j.erss.2015.08.018
D. Nicolini, Practice Theory, Work, and Organization – An Introduction. Oxford University Press, 2012.
S. Nyborg, I. Røpke, Constructing users in the smart grid – insights from the Danish eFlex project, Energy Efficiency 6(4) (2013) pp. 655-670. DOI 10.1007/s12053-013-9210-1
M. Pantzar, E. Shove, Temporal rhythms as outcomes of social practices: a speculative discussion, Ethnologia Europaea 40 (1) (2010) pp. 19-29.
G. Powells, H. Bulkeley, S. Bell, E. Judson, Peak electricity demand and the flexibility of everyday life. Geoforum 55 (2014) pp. 43-52. DOI 10.1016/j.geoforum.2014.04.014
I. Røpke, T. H. Christensen, Energy impacts of ICT – Insights from an everyday life perspective, Telematics and Informatics 29(4) (2012) pp. 348-361. DOI 10.1016/j.tele.2012.02.001
L. Schick, C. Gad, Flexible and inflexible energy engagements – A study of the Danish Smart Grid Strategy, Energy Research & Social Science 9 (2015) pp. 51-59. DOI 10.1016/j.erss.2015.08.013
E. Shove, Comfort, Cleanliness and Convenience: The Social Organization of Normality, Berg, Oxford, 2003.
E. Shove, Everyday practice and the production and consumption of time, in: E. Shove, F. Trentmann, R. Wilk (Eds.), Time, Consumption and Everyday Life: Practice, Materiality and Culture, Berg, Oxford, 2009, pp. 17-33.

E. Shove, Habits and their creatures, in: A. Warde, D. Southerton (Eds.): The habits of consumption, Helsinki: Open Access Book Series of the Helsinki Collegium of Advanced Studies, 2012, pp. 100-113.
E. Shove, G. Walker, What is energy for? Social practice and energy demand, Theory, Culture & Society 31 (5) (2014) pp. 41-58. DOI 10.1177/0263276414536746
T. Skjølsvold, M. Ryghaug, T. Berker, A traveler's guide to smart grids and the social sciences, Energy Research & Social Science 9 (2015) pp. 1-8. DOI 10.1016/j.erss.2015.08.017
J. Spradley, The Ethnographic Interview. Harcourt Brace Jovanovich College Publishers, Orlando, 1979.
D. Southerton, Habits, routines and temporalities of consumption: from individual behaviours to the reproduction of everyday practices, Time & Society 22(3) (2012) pp. 335-355. DOI 10.1177/0961463X12464228
D. Southerton, 'Squeezing Time': allocating practices, coordinating networks and scheduling society, Time & Society 12 (1) (2003) pp. 5-25. eScholarID:1b7905
D. Southerton, Temporal Rhythms: Comparing daily lives of 1937 with those of 2000 in the UK, in: E. Shove, F. Trentmann, R. Wilk (Eds.), Time, Consumption and Everyday Life: Practice, Materiality and Culture, Oxford, Berg, 2009, p. 49-63. eScholarID:111709
B. K. Sovacool, What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda, Energy Research & Social Science 1 (2014) pp. 1-29. DOI 10.1016/j.erss.2014.02.003
Y. Strengers, Smart Energy Technologies in Everyday Life, Palgrave Macmillan, Basingstoke, UK, 2013.
T. Thagaard, Systematik og indlevelse – en indføring i kvalitativ metode, Akademisk forlag, 2004. A. Warde, Consumption and theories of practice, Journal of Consumer Culture 5 (2) (2005) 131 -153. DOI 10.1177/1469540505053090
G. P. J. Verbong, S. Beemsterboer, F. Sengers, Smart grids or smart users? Involving users in developing a low carbon electricity economy, Energy Policy 52 (2013) pp. 117-125. DOI 10.1016/j.enpol.2012.05.003
G. Walker, The dynamics of energy demand: change, rhythm and synchronicity, Energy Research and Social Science 1 (2014) pp. 49-55. DOI 10.1016/j.erss.2014.03.012
A. Warde, D. Southerton, Introduction, in: A. Warde, D. Southerton (Eds.), The Habits of Consumption, Helsinki: Open Access Book Series of the Helsinki Collegium of Advanced Studies, Vol 12, 2012, pp. 1-25. eScholarID: 213905

Making sense of electric vehicle driving: Examining interventions in mobility practices

Freja Friis
Danish Building Research Institute
Aalborg University
A. C. Meyers Vænge 15
2450 Copenhagen SV DENMARK

Abstract
This paper examines the tension between the anticipated potential of electric vehicles as a smart grid technology, and associated persistently (s)low consumer adoption. This paradox is illuminated through a case study of an electric mobility operators' demonstration project, which tested the first mass-produced electric vehicles (EVs) across a variety of Danish households. The intervention marketed the smart grid technology's lower total cost of operation over a five-year period, and its ability to meet participants' driving needs. Nevertheless, a minimal number of participants wanted to invest in an electric car after the project had ended. Instead of reproducing one-dimensional techno-rational EV adoption approaches, this empirical analysis explains the low adoption rate in terms of the interlocking complexes of social practices, which are configured by, and emergent from, broader systems of interconnected practices. To release EVs' peak-shaving and storage potentials, mobility interventions need to acknowledge the intersections between systemic practices and negotiate and challenge current concepts of 'normal' mobilities.

Keywords
Smart grid, electric vehicles, adoption, mobility, social practices.

1. Introduction

Global realities of climate change and energy security require a fundamental rethinking of current unsustainable systems of energy production and consumption. One way that global governance strategies attempt to accommodate these challenges is by increasing the production of renewable energy sources. Fluctuating electricity generation from, for example, wind turbines and solar photovoltaic cells, requires flexible load-management to optimise the balance of consumption and production (Darby and McKenna, 2012; Powells et al., 2014). Here, electric vehicles (EVs) are advocated as a crucial technology to manage peak demand and reduce the world's dependence on fossil fuels (Bakker and Farla, 2015; Dijk et al., 2013; Richardson, 2013; Sierzchula et al., 2012). 'Releasing' EVs' expected energy potentials due to the technology's vehicle-to-grid connection, crucially depends on consumers' acceptance and willingness to adopt electric vehicles (Bradley and Frank, 2009; Dijk et al., 2013; Richardson, 2013). Hence, households' flexibility in finding time to recharge EVs' batteries is significant for enabling the balance of energy production and consumption (Danish Government, 2013).

However, the EV market is still very much in the nascent stage. Global and European sales figures show that EVs are below 1% of new car registrations (McKinsey&Company, 2014). Nevertheless notable differences are exhibited amongst EU Member States, caused by the different fiscal incentives provided by national governments (Pocketbook, 2014). The considerable EV fleet in Norway, compared to other nations, exemplifies how national incentive structures can work very effectively. Overall, the dominant policy assumption is that the electricification of transport and EV-adoption will be accommodated through battery advancement and the introduction of lower purchase costs (European Commission JRS, 2013). In addition, increasing research emphasises the need for; a reduction in the time taken for battery recharging, extending EV supportive infrastructures, standardisation, and fiscal measures (Brown et al., 2010; Dijk et al., 2013; Peters and Dütschke: 2014).

This paper examines a leading Danish electric mobility operator (EMO) Clever's comprehensive demonstration project 'Test an EV' (TEV) which during 2011-2014 tested the first generation of mass-produced EVs amongst 1,578 Danish households living in different parts of the country. TEV's overall aim was to change households' general negative perceptions of EVs and to collect comprehensive verified data on EVs' competitive performance. The strategy was intended to demonstrate EVs' everyday potential and to qualify future EV mobility operation. As such, TEV was designed as a crucial instrument in Clever's long-term commercial strategy to improve the nation-wide roll-out of EVs and EV charging stations.

The demo-project positively concluded that due to the highly stationary nature of EVs when parked, they had a huge smart grid potential (for electricity storage). Crucially, it also concluded that EVs enable households' everyday needs to be met to the same extent as combustion cars (Clever's final report, 2014). Other studies based on GPS data show that EVs cover the majority of everyday driving needs (Franke and Krems, 2013; Khan and Kockelman, 2012; Ramsbrock et al., 2013; Simic et al., 2014). Paradoxically however, almost all of the participants in this study found that EVs were incompatable with their everyday lives; referring to EVs' limited driving range, decreased comfort, high purchase price. Furthermore, the intervention contained some controversial aspects, particularly a strong commitment to householder participation and ongoing experimentation. In line with mainstream technology-adoption approaches, the EMO held the assumption that shifting consumers' choices through further technology innovation would lead to future widespread EV adoption. Considering the test-pilots non-adoption post the demonstration project, the operator assumed that the test-drivers' range preferences were substantially higher than their actual daily average range needs, and that there would therefore be a need to 'nudge' consumers' decision-making (Thaler and Sunstein, 2008). This intervention framing remained ideological at the end of the demo-project, as it neglected to understand how complex everyday practices shape mobility. To alter the current conception of mobility, intervention attempts should focus on reconfiguring these systemic practices either directly or indirectly.

Despite technology clearly playing a critical role in the transition to a smart energy system, transformation processes for achieving sustainable mobility, through the electrification of private transport, are still vaguely formulated. Such transformation demands difficult socio-technological changes and dramatic shifts in existing mobility practices. Recently, a growing number of socio-technical system approaches have emphasised how transition is a heterogeneous and complex affair, and have recommended that interventions recognise the complexity and seamless web character of technology and society. These researchers are also concerned about dominant assumption that technological-fixes will adequately address the urgent need to transition to a more environmentally sustainable society (Callon, 2012; Geels, 2012; Shove, 2010). These socio-technical approaches consider 'automobility' as an example of a rapid and radical socio-technical development that has reconfigured the normality of mobility demand, and which critically - particularly given its negative environmental impact - is difficult to change due to the path dependency of current automobility structures (Geels, 2012; Sheller and Urry, 2000; Urry, 2004). This position is emphasised by powerful socio-technical constructions relating to particular meanings and freedoms associated with automobility that have arisen during our late modern societies (Freudendal-Pedersen, 2007; Sachs, 1992). These approaches have provided significant impetus for mobility and consumption research, however consumer habits and routines are less represented and often overlooked in current EV research (Rezvani et al., 2015).

Considering the considerable smart grid potential of EVs and their (s)low adoption rate, this paper recognises the need to go beyond existing dominant rationales for vehicle (non)adoption that are defined by driving range and purchase price. I develop these rationales, by presenting an alternative social practice theory (SPT) based approach for understanding current mobility demand (Shove et al., 2015; Spurling and McMeekin, 2014; Watson, 2012). This analysis scrutinises Clever's EV adoption strategy by examining three policy intervention framings (Spurling and McMeekin, 2014), and illustrates a need for more ambitious interventions that recognise the dynamics of social practices, and how they configure mobility demand (and *vice versa*). By sheding light on the links, flows and relations of interconnected practices that make-up current mobility demand, this enquiry suggests that the crucial future challenge for EV interventions is to take account of driving practices as part of a broader system of practices with which they are interlocked, and to acknowledge how the 'normality' of mobility demand is produced through the performance of these interlinked practices throughout social life. My intention is not to suggest that the entire dominant paradigm is completely wrong or to criticise existing socio-technical approaches. Rather, I want to acknowledge how interventions that recognise the complexity of systemic practices – particularly in the era of decarbonisation and sustainability – have the potential to transform the social practices of which (auto)mobility is part, and in which it is enmeshed. Thus, this inquiry provides empirical analysis as to how EV adoption is challenged by the interlocking nature of car dependence (and its supporting infrastructure), and how EV driving is conjoined, linked and bonded within complex systems of social practices.

In the following section, I present a lens of social practice theory and its alternative conceptualisation of socio-technical change, as based on three policy intervention framings that attempt to change currently unsustainable mobility practices (Spurling and McMeekin, 2014). The following section briefly introduces the methods used in this analysis, and provides an introduction of my analytical case study of mobility intervention. The first part of the analysis criticises the EMO's existing intervention strategy and describes its limited success rate for improving EV uptake. Secondly, the participants' actual EV driving experiences are scrutinised, demonstrating the implications for revising the complex system of practices in which they are embroiled. Hence, I illustrate why future smart grid interventions need to acknowledge and attempt to govern systems of practices. Finally I will conclude on the analytical findings.

2. Intervention in social practices

Instead of reproducing dominant techno-rational economically and psychologically-oriented governance approaches to behaviour change and EV-adoption, SPT never reduces what people do simply to a matter of individual attitudes or choices, but always understands particular 'doings' as a performance of practice (Halkier and Jensen, 2008). To achieve adequate socio-technical change, this approach highlights the importance of acknowledging how social practices are carried out and performed by practitioners across time and space. Confronting well-established understandings that it is frequently difficult to change existing practices, not least driving, practice theorists suggest that SPT-based approaches offer a distinct social ontology that can better inform governance interventions (Shove et al., 2015; Spurling et al., 2013; Spurling and McMeekin, 2014; Strengers, 2013; Watson, 2012). SPT leads to pivotal questions being asked about, '[w]hat energy demand is for?' (Shove and Walker, 2014), and acknowledges the need to change how current demand for mobility is produced (Shove et al., 2015; Spurling and McMeekin, 2014; Watson, 2012). This approach attempts to understand the co-constructive relationship between socio-technical structures and human action. This view underpins the SPT-based framework used in this analysis, which contextualises test-drivers' driving performances as part of a complex system of daily mobility practices, which through their performance, reinforce associated infrastructures and institutions.

Configurations of social practices

As an effect of the heterogeneous approaches within theories of practice, the units configuring social practices have been variously interpreted (Gram-Hanssen, 2011). Founded on significant contributions that attempt to define a practice (Gram-Hanssen, 2011; Reckwitz, 2002; Schatzki, 1996; Shove et al., 2012), Shove et al. provide a simple conceptualisation of the three interdependent elements; materials, competences and meanings;

> "*materials* – including things, technologies, tangible physical entities, and the stuff of which objects are made; *competences* – which encompasses skill, know-how and technique, and *meanings* – in which we include symbolic meanings, ideas and aspirations" (Shove et al., 2012:14).

An important analytical distinction within practice theory is between 'practice-as-entity' and 'practice-as-performance'(Schatzki, 1996:89-90). Examining the practice of car driving, 'driving-as-entity' refers to the recognisable conjunction of elements, which can be spoken about and drawn upon as a set of resources when driving in a car. However, car driving also consists of accumulation of those incidences of doing. Thus, 'driving-as-performances' are the observable doings of particular individuals, often referred to as 'behaviours'. In this regard, car drivers are 'carriers' (Reckwitz, 2002) of particular mobility practices, that reinforce, reproduce and potentially change, current mobility patterns (Shove et al., 2012). Consequently, it is through cumulative moments of performance, the 'pattern' provided by the driving-as-entity is filled out and reproduced, as interdependencies form between the elements comprise the practice, and sustain it over time (Watson, 2012). This indicates the inherent association and constitution between the two terms. Whereas practice entities depend on repeated performances to be sustained, entities also order performances, providing potential opportunities for the composition of practices and the links between practices to change (Shove et al., 2012).

Interventions in practices

Decarbonisation of today's transport sector requires intervention in practitioners' social practices (see Shove et al., 2015; Spurling et al., 2013; Spurling and McMeekin, 2014; Watson, 2012), instead of continuing the dominant focus on (often) ineffective technical innovation and behavioural change efforts. These scholars suggest that policy interventions need to concentrate upon changing the practice elements configuring the entity of driving, and attempt to reconfigure the interconnected patterns of social practices, that are directly or indirectly linked to car driving. Considering conventional sustainable mobility policies in the United Kingdom (UK) that are based on 'technology fixes' and 'shifting consumer choices', Spurling and McMeekin developed three alternative practice-based explanations of different policy intervention approaches: (i) 'recrafting practices', (ii) 'substituting practices' and (iii) 'changing how practices interlock' (Spurling and McMeekin, 2014). These three framings distinguish between the types and scales of ambition within UK transport policy.

First, 'recrafting' practices involves changing existing practice elements in order to reduce the overall resource intensity of a practice. In regard to decarbonising the transport sector, this might entail replacing resource-intensive combustion cars with EVs, or changing traditional meanings of freedom associated with the autonomy provided by conventional cars, to being independent of petrol stations with EVs. In the case of mobility, this policy intervention attempts to reduce the amount of vehicle emissions, without challenging the scale and extent of existing driving (Spurling and McMeekin, 2014). Thus, this intervention does not challenge the existing norms and conventions of demand, but does suggest that policy interventions should seek to introduce a systemic recrafting of normalised practice elements.

Second, 'substituting' practices highlights how policy interventions that attempt to replace current unsustainable practice entities with more sustainable alternatives by changing how practitioners' needs and wants are met. To change the balance and competition between the dominant resource-intensive practices and more sustainable counterparts, require interventions in both practices at the same time (Spurling and McMeekin, 2014). A specific example is the Municipality of Copenhagen's initiative to replace car parking spaces for combustion cars, with charging stations intended for EVs (Action Plan for Green Mobility, 2012). Hence, recrafting the elements of both practices is expected to stimulate fewer performances of the less-sustainable practice, by encouraging more sustainable mobility alternatives.

Finally Spurling and McMeekin (2014) highlight interventions that alter the sequencing and/ or synchronisation of practices in order to 'change how practices interlock'. Based on recent research that illuminates conceptualisations of relations, connections and links between 'bundles' and 'complexes' of practices (Shove et al., 2012:17,81), the scholars suggest that governance interventions need to change the complex interconnections between practices, that they argue, produce *the need* for automobility. They contend that any intervention in a single practice related to car driving, has a crucial effect on the whole system of practices of which it is a part. Attempts to alter the level, scale and character of the current demand for mobility, thus puts the 'negotiability of need' onto the policy agenda (Spurling and McMeekin, 2014).

Systems of practices

Due to the acknowledged difficulty in SPT adequately accounting for radical, widescale and long-lasting socio-technical change (Watson, 2012), increasingly practice theorists highlight the need to investigate the relations that hold different practices together. To inform transition to a decarbonised transport system Watson's (2012) 'systems of practice' approach elaborates connections between car driving and more extensive systems of practices, and attempt to articulate theories of practices by drawing on socio-technical systemic approaches (Geels et al., 2015; Gram-Hanssen, 2011; Hargreaves et al., 2013; McMeekin and Southerton, 2012). Watson stresses that processes of change arise because of the shifting relative location of a practice within broader systems of practice, and he demonstrates how a particular mode of mobility, such as car driving, only can recruit and retain practitioners as long as other co-dependent practices continue to be performed.

Given this, articulating an adequate decarbonisation pathway requires an analysis of the bundles of mobility practices, and their direct or indirect dependence on a wide range of other everyday practices (and *vice versa*) in space and time. Consequently, the current unsustainable automobility regime can be understood as a system of continuously made & remade connections between and across mobility (and other) practices. Such a systemic configuration of linked practices might include practices such as; working, grocery shopping, car maintenance and leisure activities, which together contribute to enabling and sustaining a particular socio-technical mode of doing (i.e. driving). Modifying practice elements that make up driving will therefore affect related practices in this automobility system (and *vice versa*).

To accommodate the challenge of reducing fossil fuels to the necessary scale, this paper recognises the importance of governance interventions that go beyond technological and behavioural change, and instead understand how, and attempt to intervene in, the interlocking bundles of practices through which the current mobility regime is produced. At the same time, it is important to bear in mind that whilst the systemic organisation of resource-intensive everyday practices can appear difficult to change, bundles and constellations of practices often move in undetermined ways and may have the potential to change (Schatzki, 2011). Therefore, EV adoption interventions need to pay attention to the complexities and path-dependencies of the systems of practices into which they are linked, and aim to understand how to challenge interconnections between practices in these wider systems.

Based on the SPT lens, policy interventions need to reduce the demand for mobility by intervening in the organisation of everyday life. EV adoption critically depends upon changing the intersection of infrastructural arrangements that are integral to the conduct of many practices at once (Shove et al., 2015). This highlights the potential of SPT to shed light on the interactions between practices and change processes across systemic scales (Geels et al., 2015; Shove et al., 2015; Watson, 2012). However crucially to date, the systemic change of practices has not been empirically tested (Watson, 2012:491). Given this empirical gap, this paper seeks to illuminate the EMO's strategy to encourage greater EV adoption by testing Spurling and McMeekin's (2014) three forms of SPT informed policy intervention. The following analysis applies a 'systems of practice' framework to understand how EV driving as entity is performed within wider practice systems. This analysis demonstrates how interventions in the interconnected patterns of practices are crucial for accelerating decarbonisation of the transport sector.

The Action Plan for Green Mobility developed by the Municipality of Copenhagen (Denmark) exemplifies elements of this ambitious policy framing. Since 2012, several policy instruments have been implemented to encourage cycling, collective transportation and e-mobility, whilst decreasing benefits related to car driving. Concrete initiatives have included; the provision of smaller roads, fewer roads being dedicated to intensive traffic flows, more single-way traffic regulation, lower speed limits, fewer car parking spaces, and numerous of EV charging stations. Simultanously information campaigns highlight the meaning of healthier, easier and greener lifestyles (Copenhagen's Cycling Strategy 2011-2025, 2011). Over the last decade, cycling has multiplied and car- sharing initiatives have become increasingly common. Despite these strategies to both 'recraft' and 'substitute' mobility practices, the number of combustion cars is still growing in Copenhagen, illustrating how car-dependent practices are linked into wider systems and infrastructures.

It is also significant to mention the contradictions between interventions developed at the municipal scale and those developed at a national scale, for which lower taxes for conventional cars have been initiated. Hence changing how practices interlock requires attention to how different interventions operate and interrelate in wider 'systems of practice' creating and reshaping automobility. This illustrates the need to attempt to govern the systems of practices, which reproduce car dependent practices. It also suggests that there is a need to illucidate by whom, from where, with what purpose, and for who attempts to govern mobility practices should be implemented.

3. Methodology

This case study of intervention in automobility practices is based on qualitative empirical methods. Instead of judging whether or not EVs are an appropriate smart grid technology to help decarbonise society, the aim is to better understand reasons for the relatively low EV uptake in Denmark, as well as globally. Ontologically, this inquiry acknowledges material arrangements (such as, car technology and associated road and refuelling infrastructures) as crucially powerful elements that are embedded in the constitution of social practices, and help to reproduce ‘meaningful’ performances of more/ less sustainable driving practices in contemporary everyday life.

Besides email correspondence, participant observations and documentary reviews, this empirical analysis is based on qualitative interviews with a variety of relevant informants (n= 19, all lasted for 1-2 hours). The interviews with the EMO’s (Clever) project leader and project coordinator illustrate the subjective views related to designing and implementing the demonstration project from both a practical and more strategic perspective. An interview was held with the funder from the Danish Transport Authority, which provided the rationale informing the allocation of public financial support to this intervention.

EV users’ everyday perspectives are illuminated by qualitative interviews with 16 participants of the TEV trial. In accessing participants’ details (as provided by Clever), I attempted to select interviewees according to diverse parameters such as; gender, age, education, income, marital status, household size, number of children living at home, and daily driving distances. Due to the EV’s limited driving range and sensitivity to cold weather conditions, I particularly wanted to talk with participants who test-drove an EV during both the winter and summer period (further details on the interviewees are provided in Table 1.). The idea of ensuring sample diversity was that this would contribute to a fuller understanding of the complex nature of householders’ interactions with the EV technology. This relative small sample is considered as a non-representative group (Flyvbjerg, 2006) of participants that exist in different times and spaces, and that are connected through a shared interest in testing the EV technology. Rather than researching the quantitative success of particular criteria and producing ‘generalisable’ and ‘representative’ knowledge, the qualitative interviews serve to illustrate the complexity associated with attempts to integrate EVs into everyday life. Inspired by Spradley (1979), the interview guides were designed to obtain insights into the participants’ specific mobility performances, daily temporal rhythms, habits, routines and newly adopted mobility and electricity-consumption patterns.

The analysis mainly comprises interpretation of transcribed focus group interviews conducted during winter. First, this method enabled critical questions to be debated around the ‘meaning’ of EV driving (Halkier, 2010, 2002). Second, the winter group’s experiences of challenges associated with the EV engine’s performance were extra significant due to the low temperatures experienced. Third, I wanted to observe whether this group, that *were not* provided with economic incentives in the form of a dynamic tariff, were willing and able to charge the EVs at the night, and to take advantage of the EVs smart grid potential.

Table 1: Households participating in focus groups about their experiences of test-driving an EV in the suburbs North of Copenhagen, during winter 2013.

Focus-group interviews conducted in Winter 2013, suburbs North of Copenhagen								
	Focus group 1			Focus group 2		Focus group 3		
Participants*	Cevin	Bella	Max	Maya	Lily	Mark	Mia	Jacob
Age and gender	53, m*	45, f	33, m	35, f	43, f	54, m	34, f	59, m
Households size	1	4	4	4	4	3	4	2
Children	0	1h*, 1o*	2h	2h	2h	1h, 1o	2h	3o
Daily transport needs (km)	40-60	60-70	40-60	60-70	60-70	20-40	20-40	0-20

*’participants’ names are changed to ensure anonymity.
*’m’ indicates male and ‘f’ indicates female.
*’h’ indicates the number of children living at home.
*’o’ indicates children no longer living at home.

4. Presentation of the case study

As a private company, owned by five Danish utility companies, Clever's long-term business strategy is to install smart grid equipment that will manage domestic electricity consumption and enable the safe operation of the electricity grid. Consequently, the overall aim of the TEV demonstration project was to achieve comprehensive data collection on participants' experiences of test-driving an EV, and to apply these results into a model to understand EVs' smart grid performance and further develop the company's long-term business strategy. In addition to Clever's own funding and sponsorships from associated private companies, TEV received public financial support from Danish municipalities and Ministries. Hence, the project was, to a large degree, obliged to approve EVs as a critical new smart-grid technology. The intention was to promote and facilitate low-carbon EVs by verifying their attributes and advantages, as well as understanding any potential 'barriers' to operation, service requirements, and necessary scientific support required to manage the 'peak-shave' and 'storing potentials' associated with EVs (Clever's final report, 2014; Danish Transport Authority, 2012).

TEV was carried out in a particular political reality that was characterised by the Danish Government's target to be independent of fossil fuels by 2050, and their associated vision to accomplish 50% renewable energy by 2025. EVs were anticipated to be one of the potential future smart grid solutions that would help to mitigate climate change due to the capacity of their batteries to replace fossil fuels with renewable energy storage capabilities (Danish Government, 2013). As such, significant political instruments were introduced to stimulate EV market penetration. These included; EVs being exempted from vehicle registration, weight and owner tax in 2013-2015 (Registration Tax Law, 2014), and politically enabling the opportunity for EMOs to give EV owners a discount on their electricity consumption expenses related to recharging. Furthermore, in June 2012, Clever established a nation-wide charging network for EVs, which was supplied with charging ports and quick charge stations that were suitable for a wide variety of EVs.

TEV enlisted a variety of public and private actors to recruit participants and to ensure local anchoring, promotion and fundraising for the intervention. The selection of test-drivers was open, as long as the application requirements were fulfilled (which included; being willing to pay the excess costs associated with refuelling the EV batteries at home, owning a car in advance of the trial; and living in a detached house within the selected municipality). The project attempted to gather EV-driving experiences from a broad cross-section of households, and purposely included test-drivers that lived in the outskirts of larger Danish cities. The data and knowledge collected comprised both 'hard' and 'soft' data. The hard data (log-data on driving date, time, distance, battery capacity) provided knowledge on the engines' attributes that enabled valuable forecasting to be made related to electricity consumption, load patterns, driving performance and range extension. The soft data (test-drivers' personal reflections, amount of passengers, weekly driving targets, and daily blog contributions) crucially increased understandings of the test-drivers' perceptions of using an EV as part of everyday life.

TEV tested different models of the first generation of mass-produced EVs (manufactured in 2010). Since this trial, EVs have been improved in terms of their safety, design and comfort. Importantly, most recently, EVs' driving range and battery capacity have been substantially advanced. Notably, one of the tested models in the demo (Nissan Leaf) is infact still the most sold EV worldwide, and hence this technology (with appropriate maintenance) is generally considered by some as competitive as EV technology manufactured in 2015 (www.elbilsupport.dk).

5. The electric automobility intervention in practice

This section analyses the TEV intervention, as understood through Spurling and McMeekin's (2014) conceptualisation of three cross-cutting practice dynamics shaping policy interventions. After examining the EMO's framing of the 'EV-driving-as-entity', subsequent analysis examines householders' perceptions of 'EV-driving-as-performance'. For this section, householders' experiences of integrating EVs into their everyday lives become the main unit of empirical investigation.

One-dimensional techno-rational approach to EV-adoption

At first sight, Clever's EV adoption strategy corresponds with mainstream governance approaches that adopt a one-dimensional focus on changing practices through technological innovation, as evidenced through their promotion of EVs' technological advantages and benefits. Branded as Europe's largest pioneering scientific project, the TEV target was to 'break down' negative images associated with EVs, by eliminating myths that these vehicles are unsafe, more expensive, have a limited driving range, and are difficult to refuel due to a nascent EV re-charging infrastructure. Due to this overall objective, the final evaluation report of TEV positively concluded that the tested EVs suitably met consumers' needs for mobility throughout their everyday lives (Clever's final report, 2014). As proclaimed by the project leader,

> "We demonstrated that the EVs worked. We had a lot of positive feedback, some points of criticism, but generally the trial has been a success (…) we have broken down several biases which is superb, since that was the primarily target for the project" (Clever's project leader, 2013).

As such, the TEV demonstration was assumed to be successful in positively reframing public understandings of EVs' attributes, performance, and smart grid potential. Clever reproduced the dominant techno-rational perspective for socio-technical change, explaining that the paradoxically (s)low adoption of EVs was a direct consequence of technology's high purchase price, insufficient driving range, and the limited selection of EV models. The funder clarified this assumed causation,

> "It [EV adoption] has gone much slower than they [Clever] had expected. The selection of vehicles needs to be greater. The range is too limited. It is a clear limitation. Now in 2014 we get more models from Renault, Volkswagen, and BMW (…), people are creating a demand, [and] when there is a greater supply [of EVs], then it will be more likely that there is a car that will suit them" (TEV funder, 2013).

Whilst the Danish Government supported EV adoption within car-manufacturing practices, the EMO attributed the lack of political authority, in differentiating between electricity tariffs and the high taxes associated with electricity usage, as huge barriers to realising EVs' peak shaving potentials as part of the smart grid. Thus, regulation and stringent governance were anticipated as crucial policy instruments for increasing EV-adoption. Generally, the EMO relied on increasing rates of EV adoption being delivered by improvements to battery life, and reduced EV running costs (financially supported by the increasing regulation of traffic fines, electricity taxes, and duties outlined by EU and national policy). This implicit assumption that current trends would gradually lead to EV uptake, indicates the EMO's limited ambition for intervening in contemporary automobility practices to reduce current transport (energy demand and associated carbon emission) trajectories.

Overall, the EMO over-stressed how technological innovation would increase EV adoption across Denmark, and assumed that future EVs adopters would be rational decision-making consumers, that would act to make favourable individual cost-benefit decisions. Whilst this investigation demonstrates that the piloted EV technology did not correlate with the test-drivers' expectations of electric mobility practices, this paper warns against a complete reliance on technological development, and guards against purely economic or psychologically based approaches to achieving behavioural change (Shove, 2010). Such techno-rational approaches can encourage energy-intensive practices and actually increase levels of electricity demandinstead of challenging them (Nyborg and Røpke, 2011; Shove, 2010; Strengers, 2013). Given this, EVs may in fact lead to more resource-intensive mobility patterns amongst householders, as later discussed.

Attempts to 'recraft' the elements of driving

Despite largely adopting a techno-rational approach towards encouraging EV driving, the EMO simultaneously acknowledged the need for experimentation, which took the form as a distinct household engagement strategy, indicating some degree of a more multi-dimensional approach to the mobility intervention. When signing the contracts agreeing participation in the TEV trial, the test-pilots confirmed obligations including: using the EV as the household's primary car; paying any additional household electricity bill costs; weekly blogging about their experiences; completing the driving book (which provided details of each trip made); participation in various public events; and completion of questionnaires etc.

These institutional settings and 'scripts' were intended to encourage testpilots to; recharge (or load) the EVs at night, use the quick-charge stations (for free), and promote EVs throughout their social networks through sharing their EV driving experiences. In addition, information explaining 'greener' (more efficient) driving techniques intended to extend EV driving range was provided at obligatory participant meetings. The advantages of EV driving were described on the TEV trial website and in several brochures, which attempted to modify the meaning of electric driving. In particular, Clever highlighted the environmental aspects of EVs, as indicated in the following positive description of 'being a testpilot';

> "As an EV driver, you positively stand out. Driving an EV increases your comfort and safety and reduces your operating costs. As an EV driver, high fuel costs become the past and service and maintenance requirements are minimised. Furthermore, the EV plays a significant role in increasing available green transportation, and reducing noise and air pollution in cities (…). With an EV you help contribute to Denmark reaching its target of getting rid of fossil fuels by 2050 (…) you will not only make a difference for the environment and your wallet – but you will also increase your comfort through your driving experience" (Clever Pamphlet, 2011).

This focus on reframing the meaning related driving green was intended to encourage the participants to adhere to the TEV trial requirements throughout the three months. The EMO's assumption was that the participatory and (embodied) practice-based approach of the trial would help to diseminate knowledge of EVs, helping to modify how EV adoption is viewed in Denmark. The participants' opportunity to testdrive and perform a variant of their normal driving practice over a sustained period were presumed to change mind-sets, indicating that Clever indended EV adoption during TEV to form than just receipt of information. In particular, the EMO endeavoured to change the meaning associated with EV driving by conveying its environmental benefits;

> "[t]he test-pilots need to be more aware of the societal challenges that EVs need to solve. More than doing something about noise levels (…), the important point concerns the implications that EVs have to increase development of renewable energy in Denmark. It's a concrete thing that we are explicit about (…). In many cases its about providing information – the test-drivers don't have enough knowledge to figure out this causation.

Therefore information is part of our role as project coordinators (…) we are responsible for informing them about their consumer responsibilities" (Project coordinator, 2013).

Rather than adopting a purely 'technological-fix' approach (omitting the need for testpilot involvement), the EMO recognised householders' sustained driving performances and commitment to the trial, as pivotal instruments for changing the practice elements of driving. Thus, the intervention intended to recraft the existing resource intensity of driving practices by, for example: replacing the combustion engine with an electric battery (the 'materials' element); providing potential consumers with competences including energy-efficient driving and smart charging (the 'competences' element); and, not least, reframing the environmental and economic advantages of driving electric (the 'meaning' element). The experimental and participatory strategy moreover acknowledged that insights on the demand-side of driving practices are important for developing smart grid solutions as those on the supply-side. Thus, the intervention to some degree recognised transitions in driving practices as a complex socio-technical affair.

Attempts to 'substitute' conventional driving practices

Though only to a limited degree, the approach adopted for the TEV trial shares some similarities with Spurling and McMeekin's second framing of policy interventions – *'substituting practices'*. This framing has the intention of changing the balance and competition between resource-intensive and more environmentally sustainable driving counterparts, by switching the mode of combustion car driving with a less resource-intensive variant of this practice (Spurling and McMeekin, 2014). Given the rhetoric that EV driving provides a compatible driving substitute, the EMO intended to shift the 'balance of competition' between these two practice variants. The competitive and substituting aspects of these variants of driving are clarified in TEV's overall target to,

> "[c]hange the general assumption about EVs amongst the Danes, to ensure that the EV becomes part of their choice of vehicle in the future, in order to benefit the environment and energy production" (Clever's refunding application, 2011). And as written in the final report (2014), the EMO intended to, "(…) explore EVs' competitiveness compared to conventional combustion cars" (Clever's final report, 2014).

In order to make EVs competitive with conventional combustion cars, Clever highlighted their lower operating costs, their sustainability benefits, the unproblematic and convenient nature of home vehicle recharging, and the company's nation-wide well-established EV charging infrastructure.

Highlighting EVs' meaningful attributes in this way was expected to increase consumer adoption at a very ambitious level. The intervention however largely focused on substitution by articulating how 'meaningful' driving electric was compared to conventional driving, and providing and highlighting practical arrangements that would better enable EV driving in everyday life. With regards to Spurling and McMeekins' suggestion to intervene in both variants of practice by growing one and shrinking the other, Clever critically had no ambitions to minimise conventional car driving or to recraft the multiple practices converging around resource-intensive automobility. Infact, the EMO advocated decarbonisation of transport through the uptake of EVs, without challenging the Danish population's persistent demand for increased mobility. Considering the need to shift current mobility demand in more sustainable directions, this analysis recognises the need to *compare* the entity of 'resource-intensive driving' with the entity of 'EV driving' to clarify what and how EV driving can substitute conventional driving performances. This process is esssential for identifying opportunities to intervene in, and reduce the prominence of, (the elements of) resource-intensive driving practices. It is also crucial to encourage practice substitution by highlighting the benefits and competitiveness of EVs and EV driving practices over conventional petrol and diesel cars, existing transport infrastructures, and 'normal' resource-intensive driving practices.

Attempts to 'negotiate' mobility demand

The third policy intervention approach concerns 'changing how practices interlock' (Spurling and McMeekin, 2014). This framing suggests that interventions need to challenge the links between bundles and complexes of practices, to bring the 'negotiability of need and demand' to the fore and, to (re)consider what mobility is intended for (Spurling and McMeekin, 2014:87-88).

As noted, Clever had little intention to change how driving practices interlock with other practices in everyday household life, but instead sought to convince TEV trial participants that the EVs could cover 98.9% of their existing, and potential future, mobility needs. By focusing on highlighting EVs' competiveness in the market, the EMO neglected to recognise how daily driving practices are almost always performed in order to accomplish the performance of other practices, such as work, school, shopping or leisure etc. Despite the EMO largely failing to consider how current mobility trends and needs are reproduced in everyday life, Clever conceded that consumers have to abandon the notion that mobility is unlimited. This indicates an assumption made by the programme operator, that householders would simply adjust to the new technology because EV-driving could meet the majority of their daily driving needs and was the more environmentally friendly option. The operator problematised the individualistic nature of conventional driving practices, which are based on freedom, flexibility, and vehicle ownership, and which are embedded in current trajectories of the automobility regime. The following quotation illustrates the EMO's acknowledgement of the need to challenge the widespread resource-intensive conceptualisation of mobility,

> "In Denmark people buy cars according to their marginal needs. It's a known phenomenon. You buy a car according to the need to drive to the local tip [waste recycling station] two to three times per year, or for a longer vacation, or for skiing once per year" (Project leader, 2013).

In addition, the funder suggested that there is a need to change from the current model of vehicle ownership inherent to automobility, and instead suggested that future mobility interventions should be based on leasing arrangements. This would pass responsibility for ensuring EVs safety and maintenance from the drivers. In this respect, the EMO anticipated that current unsustainable mobility trends would only change when consumers acknowledge their responsibility for reducing expectations that driving offers comfort, freedom and flexibility. Hence, the project coordinator stated,

> "The main challenge is that people may feel limited in their freedom due to having to plan their journey more. Spontaneous trips and unlimited freedom of movement disappear (…). But this should be an eye-opener in relation to our current expectations of resource availability. We are able to buy more resources, but then we have an overcapacity, for instance, cars parked at home illustrate a greater supply than our needs (…). We need to acknowledge that resources are limited and that people have to share resources instead of owning them" (Project coordinator, 2013).

To a certain degree therefore, the EMO acknowledged the need to negotiate existing automobility needs, for example by changing notions of car-ownership by highlighting car-sharing opportunities and other modes of collective transportation. This suggests that the core problem restricting EV adoption is not necessarily the EVs' limited driving range, but rather a question of the potential to be mobile. During the late 20th Century, growing opportunities to be mobile (alias 'motility') were constructed as 'the good life' and coupled with concepts of unlimited flexibility and freedom. Hence, acknowledgement of available 'motility' governs how we consciously and unconsciously organise and structure our everyday lives (Freudendal-Pedersen, 2007). This brings crucial conventions, such as, freedom, flexibility, comfort, individual ownership and unlimited resources, to the political negotiating table.

The EMO highlighted 'mental barriers' as a core explanation for the substantial discrepancy between EVs assumed adaptability, and participants' limited ongoing EV adoption. Despite this acknowledgement, which to some degree recognises how powerful social conventions embed current driving performances, the EMO nevertheless concluded that; technological innovation, revised and more models of EV performance and adoption, regulatory changes, economic incentives, and increasing information provision for consumers, would be key to enabling the future mass adoption of EVs.

6. Interlocked (auto)mobility practices throughout everyday life

Following examination of intervention approaches adopted by TEV, the following discussion scrutinises the testdrivers' experiences with electric driving. This analysis aims to present an alternative explanation of low EV adoption, by illustrating how EV driving is inserted into in existing interlocked practices that embed the current mobility system and, through their performances, reproduce current demand for automobility. Considering the limited driving range of the tested EVs, and whilst acknowledging continual technical improvements to EVs, policy interventions need to change the current demand for mobility. Rather than manufacture a new demand for EVs, without seeking to address the current unsustainable demand for mobility, interventions need to understand and attempt to reorganise societies' spatial and temporal arrangement of everyday driving practices within wider systems of practice (e.g. interlocking dependencies between driving and working, shopping, education, leisure etc. practices). These practices, which are largely overlooked by transport policy interventions, are directly/ indirectly related to mobility, strongly influence the 'normality' of driving demand (Shove et al., 2015; Watson, 2012).

Generally the TEV participants linked car driving with a perceived need for; daily commuting, moving goods, conducting leisure activities, relaxation time etc. Concepts of individual freedom, flexibility and spontaneity were typically understood as crucial meanings tied to car ownership and driving (Sachs, 1992, Freudendal-Pedersen, 2007). The sequence and the duration of daily driving patterns therefore played a crucial factor in scheduling and planning bundles of interlinked everyday domestic practices (and *vice versa*). As Shove and Pantzar (2010) usefully observe, practices are conditioned by the multiple temporal demand of those practices (Pantzar and Shove, 2010), and Southerton (2012) recognises how this 'temporality of practices' is configured by collective and personal temporal rhythms (Southerton, 2012).

In addition to the 'systems of practice' approach (e.g. Watson, 2012), Southerton's concepts of 'hot-spots', cold-spots' and 'harriedness' are useful for understanding participants' rejection of the lack of flexibility of EV driving, and reluctance to reorganise domestic activities in order to 'peak-shave' and balance electricity grid fluctuations. Significantly, the feeling of 'harriedness' relates to incompatibilities, sometimes experienced with the EVs, in enabling fixed institutional events (e.g. keeping to school and work times). It also relates to personal 'cramming' of activities into 'hot spots', as characterised by the intense performance of a number of activities within a limited time period, and the requirement to multi-task (Southerton, 2012, 2003). The ability to fulfil personal temporal strategies and perform particular doings at desired times, therefore crucially depends on current practices of mobility demand.

TEV participants' objections to EV driving were often associated with their loss of control due to unexpected EV-related events that disturbed their individual temporal organisation of daily practices. In addition, some participants associated daily commuting with relaxation time spent between two 'hot spots' (e.g. between busy 'mornings' and 'working') or characterised this activity in terms of 'having some time of your own' alone in the car (also observed by Freudendal-Pedersen, 2007). Following Southerton, this relaxation time has parallels with 'cold-spots' (Southerton, 2003) (the antithesis of 'hot spots'), indicating how the car is considered as more than just a material but also provides a space for recharing one's 'batteries'. Anxieties related to running out of battery power, being uncomfortable due to the cold (when the vehicle's heating was turned off to conserve the battery power), and unreliable engines, threatened these valuable 'in-between-temporal-spaces'.

Significantly, this research emphasises how EV driving crucially competed with other everyday practices for time, and further how personal scheduling and collective and institutional rhythms, challenged the ability for EV driving performances to take hold. Further, distances associated with daily commuting, and time of year (and weather conditions) proved to be substantial factors influencing whether trial participants considered future investment in an EV. The following quotations illustrate how testpilots' everyday needs, doings, and norms of automobility are challenged by the complicated planning and coordination requirements presented by the introduced EV technology,

> "It's… that actually it doesn't matter how the car looks or what [fuel] it runs on, the crucial thing is that I just want it to work as usual, then everything would be fine for me" (Lily, 43).

This quote illustrates the testpilots' dominant expectation that EV driving should enable 'normal' mobility and the high value placed on keeping everyday life as it used to be. Further the 'EV-driving-as-performance' generally increased test-drivers' logistical planning and reduced norms of comfort and convenience as experienced with conventional driving,

> "All these thoughts of logistics. I can't drive as far as I need to do the things I've planned in my everyday life (…) I have to think much more about my transportation. I haven't had the spontaneity to take a detour when somone calls me on the road, and things like that. All the time I had to plan, 'Oh alright, what am I going to do today? Which car should I take?' I'm simply used to expecting that the car isn't something that I have to think about, right? It's just there and simply works. It has been way too difficult thinking about these logistics…" (Bella, 45).

In particular, restrictions in everyday scheduling were introduced due to the need to regularly recharge the EV battery, which interrupted tightly coordinated everyday household activities, which the majority of participants were not willing to sacrifice or change. Indeed, EV driving was shown to require forward-looking planning skills, as stressed by another participant,

> "When I get home there are very few additional kilometres to run on, which means that you really have to consider what to do next (…) some days I had to drive home early from work to recharge the battery and get it ready for my evening activities" (Cevin, 53).

All of the TEV participants requested the opportunity to recharge their EV batteries at their work places. Moreover, attempts to adapt to the required logistics of EV driving also led to greater relational coordination of practice performances between family members. Supporting Clever's assumptions, the testpilots declared that the tested EVs' driving range was able to meet their daily commuting needs, which emphasises the observation that normalising 'motilities' as part of everyday life has a powerful impact. Indeed, a participant living in the suburbs of Copenhagen emphasised,

> "Given where we live today the EV would make a fine alternative [to a conventional car]. Though it can't replace car number one. If you forget about the price and security and cold, and all those things, range-wise we could get by with it" (Max, 33).

The EMO promoted the EV technology as a compatible substitute to conventional driving, in terms of being able to fulfil the complex arrangement of daily activities that make-up and structure everyday life. The following extract from a discussion between two women clearly clarifies the tight planning and organisation schedules required to complete a range of social practices undertaken as part of their daily lives.

Maya:	"I go to yoga once per week in the evening a few kilometres away which I couldn't go to without a car.
Lily:	So in fact the EV has a great capacity for driving to and from work, but its all the other things you have to do in your daily life.
Maya:	Small things matter.
Lily:	Which makes it complicated to…
Interviewer:	So commuting is not the challenge?
Lily:	No, it's everything else.
Maya:	It's all the small things. You have to go shopping for groceries, then you suddenly need some milk, and it's definitely a must to have power [in the battery] for that.
Lily:	But also to, oh yes, then your old mother calls and asks you to drive by and pick her up.
Maya:	'Sorry unfortunately I do not have power for that' (…) Yes, you can't make a spontaneous detour, it [the EV] can't.
Interviewer:	So we can't be as impulsive, you could say?
Maya:	The flexibility disappears. Although I have a very structured day, it's simply too annoying to be tied up [dependent on the EV]".

This conversation illustrates how driving is involved, interlinks and overlaps with many other daily practices, confirming how driving practices are involved in multiple systems of practices, and shedding light on why (unreliable) performances of EV driving frequently disrupted these systemic arrangements. Significantly, this indicates how EVs temporaraily modified the configurations of these systems (both temporally and spatially), which the testpilots were commonly not prepared to accept. Further, the above conversation shows how the current concept of mobility is strongly associated with being independent of others, and with having the flexibility and freedom to reschedule everyday practice performances when necessary.

These existing configurations of systems of practices, whilst continually being made and remade, were particularly challenged in the winter, when EV-driving was experienced as unsafe, uncomfortable and stressful. This is clarified in the following conversation between three test-drivers undertaking the TEV trial during the winter period, Bella: “I have not the slightest doubt that we won’t have an EV after we've tried it. I have been freezing crazy much! (...) Holy shit you’re freezing and you can barely get warm when you come inside again, because your hands and feet are simply deep-frozen! You get so cold, because of your eagerness to save as much heat as you can in the car so that you can drive as far as possible. We’ve been sitting with blankets and duvets and wearing both hats and gloves to ride from Allerød to Copenhagen… 35 kilometres. Oh no, the EV is no alternative for us.

Max: Well, we used electric heaters in the morning to warm it up.

Cevin: Well, I've also often thrown an electric fan into the car in the morning simply to get it defrosted. If you don’t, then you first have to scrape ice off the window outside and then inside (...) in our Danish climate I must say, this test model is not suitable here.

Bella: [y]ou just don’t want to turn your standard of living back fifty years, not in terms of driving comfort, otherwise the EV has been very good. But for security purposes (...) you’re not willing to sit with a cloth and wipe the glass down like your parents and grandparents”.

The recursive relationship between the ‘temporality of practices’ and the interlocked (auto)mobility system was also shown to be strongly affected by personal schedules and particular situated contexts. None of the TEV participants were willing to adopt an EV post trial completion, because of the engine’s ability to modify existing practice systems overlapping in the domestic context, and the EV’s threat to ‘normal’ social conventions, however the degree of acceptance differed considerably with family size, number of children, commuting needs, place of residence etc. Certainly families with young children that needed to adhere to school/work opening hours (institutional rhythms) particularly highlighted problems associated with their decreased ability and flexibility to integrate the smart grid technology. Previous research by Nicholls and Strengers correspondingly describes how families are often more inflexible when it comes to adopting and integrating smart grid technologies in their hectic everyday lives (Nicholls and Strengers, 2015).

Instead of reproducing common techno-rational explanations of (s)low adoption of EVs by consumers, my analysis explains this trend, and the results of the TEV trial, as a product of the interconnected complexes of, and relations between, everyday social practices, which driving is configured by and emergent from. As well as available infrastructures that help embed these systemic practices, daily temporal contraints, and institutional norms were shown to influence the role of driving in this system. Social conventions, in particular, are crticial for how driving interacts within this complex of social practices. In fact, Urry (2004) points out how our current automobility system has configured a certain need for mobility and comfort, which seems almost impossible to change.

As previously noted, the demo-project increased the existing mobility needs of the TEV trial interviewees, which paradoxically reduced cycling rates and the use of public transportation, and crucially often reinforced the desire for a household to operate an extra car. This can be seen in the following extract,

Mia: “My husband has also been happy during this period because he could use our own car. I usually take the car and he takes the train. But in this period of having two cars I took the EV, and my husband took our own car.

Interviewer:	Does this mean that you're now tempted to have an additional car?
Mark:	It has been good to have an extra car and to avoid cycling. I've gained five kilos extra weight (…) but it has been nice to avoid all the coordination related to only having one car. I've often had to drive to Herlev, where my wife works, to pick her up, which has been avoided.
Mia:	We've also used both cars at once. My husband has been happy to avoid commuting by train this winter".

This analysis illustrates how the TEV smart grid intervention reproduced and reinforced, rather than recrafted, resource intensive driving. Critically, the intervention generated some unintended negative side-effects. Instead of enabling a pathway for the decarbonisation of the current transport system, the EV testing trial increased household electricity-demand, by actually increasing levels of driving and introducing the use of heaters to warm the EV engines and replacing walking, cycling, and train transport. Furthermore, the participants from the focusgroups recharged the EVs when they came home from work, and this enhanced the electricity load on the grid during peak hours. In other words, EVs' smart grid potentials were largely not released during the TEV test-period and the 'myths' around EVs being incompatible with everyday life were not removed, rather quite the contrary.

Instead of increasing notions of comfort and convenience when EV driving and developing less ressource-intensive driving practices, the TEV intervention largely had the opposite effect. In part, this is due to the demo-project's 'rules' and 'frames' (for example, the requirement of owning a car in advance etc.), and the EMO's lack of ambition to negotiate current levels of broader automobility demand. In the main however, this can be explained by Clever's largely one-dimensional focus on a technological fix (provision of the EVs) and provision of information to consumers. This approach neglect the core challenges facing a current system of practices that is structured around existing automobility levels, and which continuously reconfigures automobility demand to successfully enable the performance of interrelated complexes and bundles of practices.

Counter to this approach, this paper calls for transport governance initiatives and interventions that explicitly take account of the intersections between systemic practices, of which automobility is part. Despite, the EMO to some extent acknowledging the importance of gaining practical knowledge about how Danish householders' EV-driving performances were conducted over a mid-range period, this intervention failed to recognise the radical and systemic changes required in order to negotiate down unsustainable driving needs. Future interventions should crucially be aware about entrusting private companies (such as Clever) the responsibility to intervene in households' everyday practices, which is why this enquiry suggests that a wide range of actors and public initiatives are need to help pave the way for a transition towards a fossil-free transport sector and society.

7. Conclusion

Based on a qualitative study of Danish households' test-driving experiences, this paper sought to uncover the disconnect between claims that EVs meet households' total driving needs, and their realised (s)low uptake. Given the global 'hype' about EVs' huge decarbonisation potentials, paradoxically none of the participants in the demo-project 'Test-an-EV' wanted to invest an EV after the three months of test-driving. Examining the clash between the EMO's positive framing of the potential for EVs to be easily adopted as a smart grid technology, and participants' experiences of EV driving in practice, this paper has attempted to 'make sense of' the realities of electric driving. By examining the complexity of driving habits and routines as embedded in householders' real-life schedules, conventions and experiences, a practice-based approach has illustrated the need for future automobility interventions to recognise the fundamental spatio-temporal 'settings' of people's interconnected and systemic social practices.

Whilst there is growing recognition of the need for widescale socio-technical transitions for sustainability, policy intervention approaches encouraging EV adoption are dominated by a largely one-dimensional focus on technological innovation and attempts to change peoples' attitudes and values so that they will behave differently. This study examined an EMO's strategic implementation of EVs within participating households' everyday lives over a three-month period. Following dominant research and policy approaches, this smart grid intervention was underpinned by core assumptions that enhanced technological functioning and information provision would provide key drivers to accomodate the required 'flexibility' necessary to drive and (re)charge an EV. Moreover, the EMO assumed that large-scale EV adoption would be acquired with improvements to EV battery capacity, increased diversity of car models, and reduced purchase prices, and therefore expected that the 'smart' grid potential of EVs would be released through regulation, economic incentives and technological innovation. Instead of focusing on the participants' rational decision-making in relation to EV driving, this enquiry highlights the need to recognise how configurations of collective practice performances interrelate and overlap, leading to unsustainable levels of inconspicuous electricity consumption occurring throughout everyday life.

The TEV intervention to some extent acknowledged participants' practical experiences and experimentation as a fundamental means to understand and encourage EV adoption. Reflecting Spurling and McMeekin's (2014) three practice-based framings of policy interventions, the EMO attempted to recraft the 'meaning' element of EV driving by; framing the environmental sustainability aspects of EV driving in terms of consumer 'responsibility', 'cleaner conscience' and by encouraging test-drivers to adhere to the project's rules. The EMO promoted electric driving largely by highlighting the sustainability aspects of EV driving, by emphasising the engine's ability to meet householders' daily mobility needs, and by pointing to the lower total cost of ownership compared to conventional driving. Moreover and perhaps most controversially, the operator recognised the test-drivers' 'mental barriers' to EV driving, which indicated some recognition of the need to (re)negotiate the current concept of automobility. Thus, the TEV intervention (to some degree) attempted to 'recraft' and 'substitute' conventional driving practices, but failed to consider 'how practices are interlocked', which this paper recognises to be essential to acknowledge and understand as part of sustainability transition attempts.

Instead of challenging and/ or changing how today's social practices are interlocked with high levels of automobility practices and car dependency, the EMO's intervention coproduced mainstream notions around contemporary mobility needs. Awkwardly, this research found that participation in the TEV trial actually increased current mobility demand by enhancing the need for a second car, and replaced daily walking and cycling practices with driving. Households' integration of EVs within their daily lives and their practical experiences of EV driving actually highlighted how having an extra car in the household would increase levels of convenience and comfort. Despite TEV promoting an eco-friendly product, this illustrates how interventions with techno-rational assumptions can have unintended consequences that actually increase resource-intensive practices. This underpins the urgent need to take the dynamics of interrelated systems of practice into account when attempting to change the sustainability levels of automobility. Further, interviews with the winter testpilots demonstrated that the EVs were inappropriate in terms of their comfort, convenience, security and price. In particular, the cold engines and limited driving range failed to meet the participants' expectations, and as such EVs were considered as stressful and unacceptable from an everyday life perspective.

This analysis suggests future smart grid interventions need to reconsider their persistent positive framing of EVs as a real alternative to conventional driving practices. Instead of framing EVs as fully compatible with consumers' everyday needs, future mobility interventions should be aware of how existing (auto)mobility practices are connected to powerful notions of freedom, comfort, flexibility and independence. EV driving interventions need to instead challenge current ideas that 'the good life' is tightly linked to 'motility', which confers limitless possibilities. Future automobility interventions need to redefine the concept of mobility, and instead promote how EVs enhance peoples' 'quality of life', as related to be 'free' of time spent refuelling at petrol stations, 'free' from polluting our society and environment, and even 'free' from the oil-industry. Moreover, effective interventions need to acknowledge the material arrangement that car dependent social practices are embedded in, and intervene in the infrastructural conduct of practices.

The empirical analysis reveals how the EV technology proved incompatible with the bundles and complexes of social practices that made up the testpilots' everyday lives, because of their reliance on conventional cars' 'normal' ability to carry out these diverse activities and duties. Understanding how driving practices intersect and overlap with other (domestic) practices is crucial for future (mobility) interventions, in order to bring the negotiability of the need for automobility to the political negotiating table, and to attempt to change the level, scale and character of current automobility demand. The study emphasises that it is important to understand how links are established and maintained, not just between elements of a single EV driving practice, or between two modes of practice (e.g. conventional versus EV driving), but also between and across multiple systemic practices (such as employment, social care, food provisioning practices etc). EV driving will struggle to recruit and retain practitioners as long as other co-dependent practices continue to be performed. This therefore requires future smart grid interventions to acknowledge and examine the matrix of bundles and complexes of spatio-temporally dynamic practices that make up everyday life. Acknowledging this interlocked system of synchronised social practices provides an alternative explanation as to why EV driving hasn't yet gained momentum in Denmark, or further afield.

Adopting this alternative understanding of EV adoption, and seeking wide-scale smart grid solutions and long-term sustainable transitions, this paper recommends the involvement of multiple actors in automobility interventions, and looking outside the corporate provision of technological infrastructures. Future mobility intervention strategies need to involve a wide set of potential change agents when attempting to release EVs peak-shaving potentials, and should take care when entrusting private companies with the responsibility of achieving less resource-intensive (auto)mobility patterns. This paper has begun to open up this conversation, and has advocated understanding (auto)mobility as part of a complex of interrelated systemic pratices that make up everyday life, however there is an urgent need to identify which actors will come together to govern current unsustainable transport practices and how best to change the path dependency of currently unsustainable driving practices.

Acknowledgement

This work is a part of the 'IHSMAG' project, which contributes to develop integrative smart grid solutions that take the technical and social context of households into account. IHSMAG is supported by the Second ERA-Net Smart Grid Joint Call. I am especially grateful for very valuable supervision from Dr. Tom Hargreaves, School of Environmental Sciences, and revision made by Postdoctoral Research Associate

Rachel Macrorie. Also thanks for constructive feedback from my supervisor Kirsten Gram-Hanssen and Toke Haunstrup Christensen, Aalborg University.

8. References

Action Plan for Green Mobility, 2012. Copenhagen Municipality, Copenhagen.

Bakker, S., Farla, J., 2015. Electrification of the car – Will the momentum last? Introduction to the special issue. Environ. Innov. Soc. Transit. 14, 1–4. doi:10.1016/j.eist.2014.07.002

Bakker, S., Jacob Trip, J., 2013. Policy options to support the adoption of electric vehicles in the urban environment. Transp. Res. Part Transp. Environ. 25, 18–23. doi:10.1016/j.trd.2013.07.005

Registration Tax Law. Bekendtgørelse af lov on registreringsafgift af motorkøretøjer m.v., 2014. (accessed 5.23.16).

Bradley, T.H., Frank, A.A., 2009. Design, demonstrations and sustainability impact assessments for plug-in hybrid electric vehicles. Renew. Sustain. Energy Rev. 13, 115–128. doi:10.1016/j.rser.2007.05.003

Brown, S., Pyke, D., Steenhof, P., 2010. Electric vehicles: The role and importance of standards in an emerging market. Energy Policy, Large-scale wind power in electricity markets with Regular Papers 38, 3797–3806. doi:10.1016/j.enpol.2010.02.059

Callon, M., 2012. Society in the making: The study of technology as a tool for sociological analysis, in: Bijker, W.E., Hughes, T.P., Pinch, T. (Eds.), The Social Construction of Technological Systems - New Directions in the Sociology and History of Technology. The MIT Press, Cambridge, Massachusetts London, England, London.

Clever Pamphlet, 2011. Electric Vehicles and charging, which suit your demands. Clever, Copenhagen.

Clever's final report, 2014. Clever, Copenhagen (accessed 5.22.15).

Clever's refunding application, 2011. Clever, Copenhagen.

Copenhagen's Cycling Strategy 2011-2025, 2011. Copenhagen Municipality, Copenhagen.

Danish Government, 2013. Smart Grid Strategy: The intelligent energy system of the future.

Danish Transport Authority, 2012. Minute on Electric Vehicles.

Darby, S.J., McKenna, E., 2012. Social implications of residential demand response in cool temperate climates. Energy Policy 49, 759–769. doi:10.1016/j.enpol.2012.07.026

Dijk, M., Orsato, R.J., Kemp, R., 2013. The emergence of an electric mobility trajectory. Energy Policy, Special Section: Transition Pathways to a Low Carbon Economy 52, 135–145. doi:10.1016/j.enpol.2012.04.024

European Vehicle Market Statistic: Pocketbook 2014, 2014. The International Council on Clean Transportation.

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qual. Inq. 12, 219–245. doi:10.1177/1077800405284363

Franke, T., Krems, J.F., 2013. Interacting with limited mobility resources: Psychological range levels in electric vehicle use. Transp. Res. Part Policy Pract., Psychology of Sustainable Travel Behavior 48, 109–122. doi:10.1016/j.tra.2012.10.010

Geels, F.W., 2012. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. J. Transp. Geogr., Special Section on Theoretical Perspectives on Climate Change Mitigation in Transport 24, 471–482. doi:10.1016/j.jtrangeo.2012.01.021

Geels, F.W., McMeekin, A., Mylan, J., Southerton, D., 2015. A critical appraisal of Sustainable Consumption and Production research: The reformist, revolutionary and reconfiguration positions. Glob. Environ. Change 34, 1–12. doi:10.1016/j.gloenvcha.2015.04.013

Gram-Hanssen, K., 2011. Understanding change and continuity in residential energy consumption. J. Consum. Cult. 11, 61–78. doi:10.1177/1469540510391725
Halkier, B., 2010. Focus groups as social enactments: integrating interaction and content in the analysis of focus group data. Qual. Res. 10, 71–89. doi:10.1177/1468794109348683
Halkier, B., 2002. Fokusgrupper, 1. udgave. ed. Samfundslitteratur & Roskilde Universitetsforlag.
Halkier, B., Jensen, I., 2008. Det sociale som performativitet - et praksisteoretisk perspektiv på analyse og metode. Dan. Sociol. 19, 49–68.
Hargreaves, T., Longhurst, N., Seyfang, G., 2013. Up, down, round and round: connecting regimes and practices in innovation for sustainability. Environ. Plan. A 45, 402–420. doi:10.1068/a45124
JRS News Release: A look at the EU's research on electric cars, 2013.
Khan, M., Kockelman, K.M., 2012. Predicting the market potential of plug-in electric vehicles using multiday GPS data. Energy Policy 46, 225–233. doi:10.1016/j.enpol.2012.03.055
McKinsey&Company, 2014. Evolution: Electric vehicle in Europe: gearing up for a new phase. Amsterdam Roundtable Foundation.
McMeekin, A., Southerton, D., 2012. Sustainability transitions and final consumption: practices and socio-technical systems. Routledge, Technology Analysis & Strategic Management Vol. 24, 345–361.
Nicholls, L., Strengers, Y., 2015. Peak demand and the "family peak" period in Australia: Understanding practice (in)flexibility in households with children. Energy Res. Soc. Sci. 9, 116–124. doi:10.1016/j.erss.2015.08.018
Nyborg, S., Røpke, I., 2011. Energy impacts of the smart home - conflicting visions. ECEEE 2011 Summer Study Proc. Energy Effic. First Found. Low-Carbon Soc. 4, 1849–1860.
Pantzar, M., Shove, E., 2010. Temporal rhythms as outcomes of social practices: a speculative discussion. Ethnol. Eur. 40, 19–29.
Powells, G., Bulkeley, H., Bell, S., Judson, E., 2014. Peak electricity demand and the flexibility of everyday life. Geoforum 55, 43–52. doi:10.1016/j.geoforum.2014.04.014
Ramsbrock, J., Vilimek, R., Weber, J., 2013. Exploring electric driving pleasure–the BMW EV pilot projects, in: Human-Computer Interaction. Applications and Services. Springer, pp. 621–630.
Reckwitz, A., 2002. Toward a Theory of Social Practices: A Development in Culturalist Theorizing. Eur. J. Soc. Theory 5, 243–263. doi:10.1177/13684310222225432
Rezvani, Z., Jansson, J., Bodin, J., 2015. Advances in consumer electric vehicle adoption research: A review and research agenda. Transp. Res. Part Transp. Environ. 34, 122–136. doi:10.1016/j.trd.2014.10.010
Richardson, D.B., 2013. Electric vehicles and the electric grid: A review of modeling approaches, Impacts, and renewable energy integration. Renew. Sustain. Energy Rev. 19, 247–254. doi:10.1016/j.rser.2012.11.042
Schatzki, T., 2011. Where the action is (on large social phenomena such as sociotechnical regimes). Sustain. Pract. Res. Group Work. Pap. 1.
Schatzki, T., 1996. Social practices: A Wittgensteinian Approach to Human Activity and the Social. Cambridge University Press, New York.
Sheller, M., Urry, J., 2000. The city and the car . International Journal of Urban and Regional Research, vol. 24, 737-757.
Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environ. Plan. A 42, 1273–1285. doi:10.1068/a42282
Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and How it Changes, The Dynamics of Social Practice: Everyday Life and How it Changes. London: Sage.
Shove, E., Walker, G., 2014. What Is Energy For? Social Practice and Energy Demand. Theory Cult. Soc. 263276414536746. doi:10.1177/0263276414536746

Shove, E., Watson, M., Spurling, N., 2015. Conceptualizing connections: Energy demand, infrastructures and social practices. Eur. J. Soc. Theory. doi:10.1177/1368431015579964

Sierzchula, W., Bakker, S., Maat, K., van Wee, B., 2012. The competitive environment of electric vehicles: An analysis of prototype and production models. Environ. Innov. Soc. Transit. 2, 49–65. doi:10.1016/j.eist.2012.01.004

Simic, D., Stark, J., Bäuml, T., Link, C., 2014. Required range of electric vehicles – an analysis of longitudinal mobility data. IET Intell. Transp. Syst. 9, 119–127. doi:10.1049/iet-its.2013.0019

Southerton, D., 2012. Habits, routines and temporalities of consumption: From individual behaviours to the reproduction of everyday practices. Time Soc. 22, 335–355. doi:10.1177/0961463X12464228

Southerton, D., 2003. Squeezing time: Allocating practices, coordinating networks and scheduling society. Time Soc. 12, 5–25.

Sovacool, B.K., Hirsh, R.F., 2009. Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. Energy Policy 37, 1095–1103. doi:10.1016/j.enpol.2008.10.005

Spradley, J.P., 1979. The Ethnographic Interview, (11.printing ed.). ed. Fort Worth: Holt, Rinehart and Winston, New York.

Spurling, N., McMeekin, A., 2014. Interventions in practices, in: Social Practices, Intervention and Sustainability - Beyond Behaviour Change.

Spurling, N., McMeekin, A., Shove, E., Southerton, D., Welch, D., 2013. Interventions in practice: re-framing policy approaches to consumer behaviour, Sustainable Practices Research Group.

Strengers, Y., 2013. Smart Energy Technologies in Everyday Life - Smart Utopia? Palgrave Macmillan, Basingstoke.

Thaler, R.H., Sunstein, C.R., 2008. Nudge: Improving Decisions about Health, Wealth, and Happiness. Yale University Press.

Urry, J., 2004. The “system”of automobility. Theory Cult. Soc. 21, 25–39.

Watson, M., 2012. How theories of practice can inform transition to a decarbonised transport system. J. Transp. Geogr., Special Section on Theoretical Perspectives on Climate Change Mitigation in Transport 24, 488–496. doi:10.1016/j.jtrangeo.2012.04.002

ISSN (online): 2246-1248
ISBN (online): 978-87-7112-717-1

AALBORG UNIVERSITY PRESS